NASA Tech Briefs

Official Publication of
National Aeronautics and
Space Administration
Volume 16 Number 5

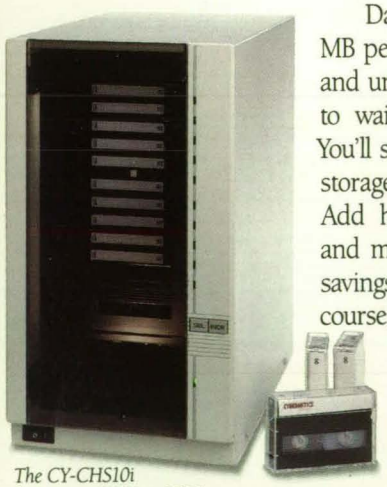
Transferring Technology
to Industry and
Government
May 1992

Dynamic Device Gives Telerobots "Human Touch"

YOU'RE LOOKING AT TWO 8MM TAPE DRIVES.

THAT'S RIGHT.

Our CY-8500 now gives you complete backwards compatibility with our popular CY-8200. With the flip of a switch, the CY-8500 can read and write tapes in CY-8200 mode. Making it possible for one tape drive to store between 2.5 and 25 GB, completely unattended. It's like getting two drives for the price of one.



The CY-CHS10i features an 8200 or 8500, ten tapes, and stores up to 250 GB.

Data transfer rates of up to 90 MB per minute let you backup fast and unattended. So you won't have to wait around to change tapes. You'll save money in reduced media, storage and shipping costs, too. Add hardware data compression and multiply capacity, speed – and savings – by up to five times. Of course, data compression is switch-selectable, so you can read and write tapes without compression for compatibility with other sites.

We're pushing the limits of flexibility, making tape drives that will perform exceptionally today – and tomorrow. Giving you true "plug and play" compatibility with the widest range of systems interfaces on the market. Plus a clear upgrade path through the product line.

TRUE "PLUG-AND-PLAY" COMPATIBILITY WITH:

Alliant	Gould/Encore	PS/2
Alpha Micro	HP	PC 386/ix
Altos	IBM AS/400	PC MS-DOS
Apollo	IBM Mainframe	PC Xenix/Unix
Arix	IBM RISC/6000	Pertec
AT&T	IBM RT	Plexus
Basic-4	IBM S/38	Prime
Concurrent	ICL	Pyramid
Convergent	Intergraph	Sequent
DataGeneral	Motorola	Silicon Graphics
DEC 3100/5000	Macintosh	Stratus
DEC BI-Bus	McDonnell Douglas	Sun
DEC HSC	NCR	Texas Instruments
DEC Q-Bus	NeXT	Unisys
DEC TU/TA81	Novell	Wang
DEC Unibus	OS/2	*and more*

Our complete family of data storage subsystems includes QIC tape streamers, magneto-optical disk drives, 8mm tape drives and 8mm tape libraries.

There's no better value in 8mm tape backup than the CY-8500. Call today for complete information at (804) 873-9000.

Rock Landing Corporate Center • 11846 Rock Landing, Newport News, VA 23606
FAX 804/873-8836

Europe Tel: +31 8385 51708 FAX: +31 8385 50596 **Scandinavia** Tel: +47 2 79 58 80 FAX: +47 2 78 36 01
France Tel: +33 88 67 12 45 FAX: +33 88 66 79 19 **Japan** Tel: +81 3 3639 5841 FAX: +91 3 3639 5865
U.K. Tel: +44 7373 73544 FAX: +44 7373 62813 **New Zealand** Tel: +64 9 479 1100 FAX: +64 9 479 8009
R.O.C. Tel: +886 2 5068702 FAX: +886 2 5014198 **U.S.** FAX: 804 873 8836

CONTEMPORARY CYBERNETICS Group

For More Information Circle No. 322

MATLAB™

High-Performance Numeric Computation and Data Analysis

MATLAB has rapidly become an industry standard for engineering and scientific research. Its unique interactive interface, algorithmic foundation, easy extensibility, and speed make MATLAB the software system of choice for ***high productivity and high creativity*** research.

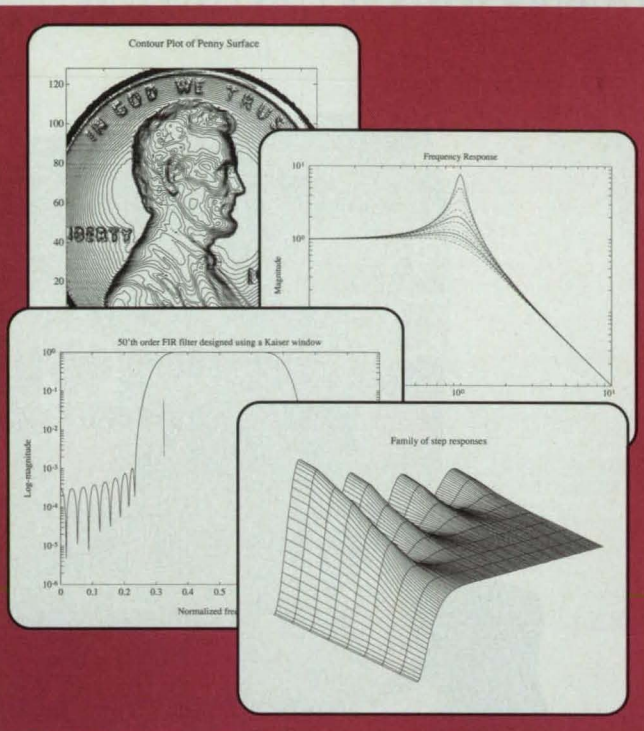
Problems and solutions are expressed just as they are written mathematically—***without the need for traditional programming***. As a result, you can solve numerical problems in a fraction of the time required to write a program in Fortran, Basic, or C. Then plot the results as 2-D and 3-D graphics, with publication-quality output to plotters, dot-matrix printers, and laser printers.

"I can create algorithms so easily that it almost seems like cheating."

Personal Engineering & Instrumentation News

Add to MATLAB your choice of tools for digital signal processing, system identification, control system design, and more. MATLAB's open-system design lets you see the algorithms and the implementations, even change them to suit your specific requirements.

MATLAB is developed by The MathWorks, a leader in software for data analysis and mathematics. Our users—in thousands of companies and universities—know that MATLAB enables them to work more creatively and productively. Take a look at how MATLAB can do the same for you.



"MATLAB is the undisputed choice for computation-intensive engineering work."

Macworld

"MATLAB's power and ease of use go a long way toward taking the drudgery out of repetitive analysis projects."

IEEE Spectrum

Over 300 Built-In Functions

- eigenvalues
- matrix arithmetic
- matrix decompositions
- convolution
- spectrum estimation
- complex arithmetic
- 1-D and 2-D FFTs
- filtering
- curve fitting
- cubic splines
- Bessel functions
- elliptic functions
- nonlinear optimization
- linear equation solving
- differential equations
- polynomial arithmetic
- descriptive statistics
- 2-D and 3-D graphics

Plus Toolboxes for:

- digital signal processing
- parametric modelling
- control system design
- chemometric analysis, and more

Computers supported

PCs and ATs
386-based PCs
Macintosh
Sun
Apollo
HP 9000/300
DECstation
VAX/VMS
VAX/Ultrix
Stardent
Convex
Encore
Alliant
Cray
and more

To find out more about **MATLAB**, call us at **(508) 653-1415**. Or simply return the completed coupon to the address below. Dealer inquiries are invited. Please call (508) 653-1415 x439.

Name _____

Company _____

Department _____

Address _____

City, State _____

Zip _____ *Country* _____

Telephone _____

Computer(s) _____

The MATH WORKS Inc.

Cochituate Place, 24 Prime Park Way
Natick, MA 01760
Phone: (508) 653-1415
Fax: (508) 653-2997

NASA 5/92

For More Information Circle No. 503

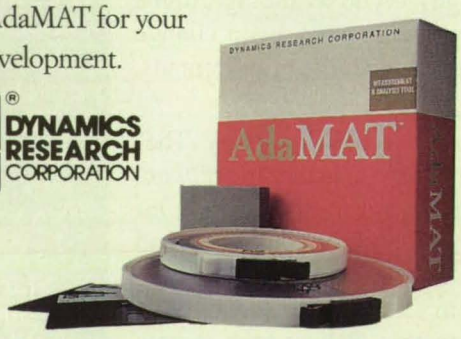
YOU CAN DEVELOP ADA CODE WITHOUT ADAMAT.™ OF COURSE, YOU CAN SKYDIVE WITHOUT THIS, TOO.

The fact is, when you write Ada code without using AdaMAT™ you're really putting the quality of your code at great risk. To be frank, you're actually inviting poorly written, unclear and inconsistent code that guarantees errors during development.

AdaMAT is quite simply, the most valuable and crucial software engineering tool that is available today to Ada program developers. It is the only tool for the prevention of errors during development. AdaMAT analyzes Ada code and evaluates it using key quality characteristics that are based on the most effective use of the language.

With the use of AdaMAT, potential errors are detected prior to testing. It lets programmers insure the quality of their code earlier in development when errors are much less time-consuming and costly to fix. So avoid the pitfalls. Get your project in on time and right on budget. Write clean, consistent, accurate, reliable Ada code. And do it whether you're developing in the Rational, VAX, SUN, or SCO/UNIX environments. Call us today at 1-800-522-7321 for complete information. We'd jump at the chance to tell you all about the immediate benefits you'll receive using AdaMAT for your Ada development.

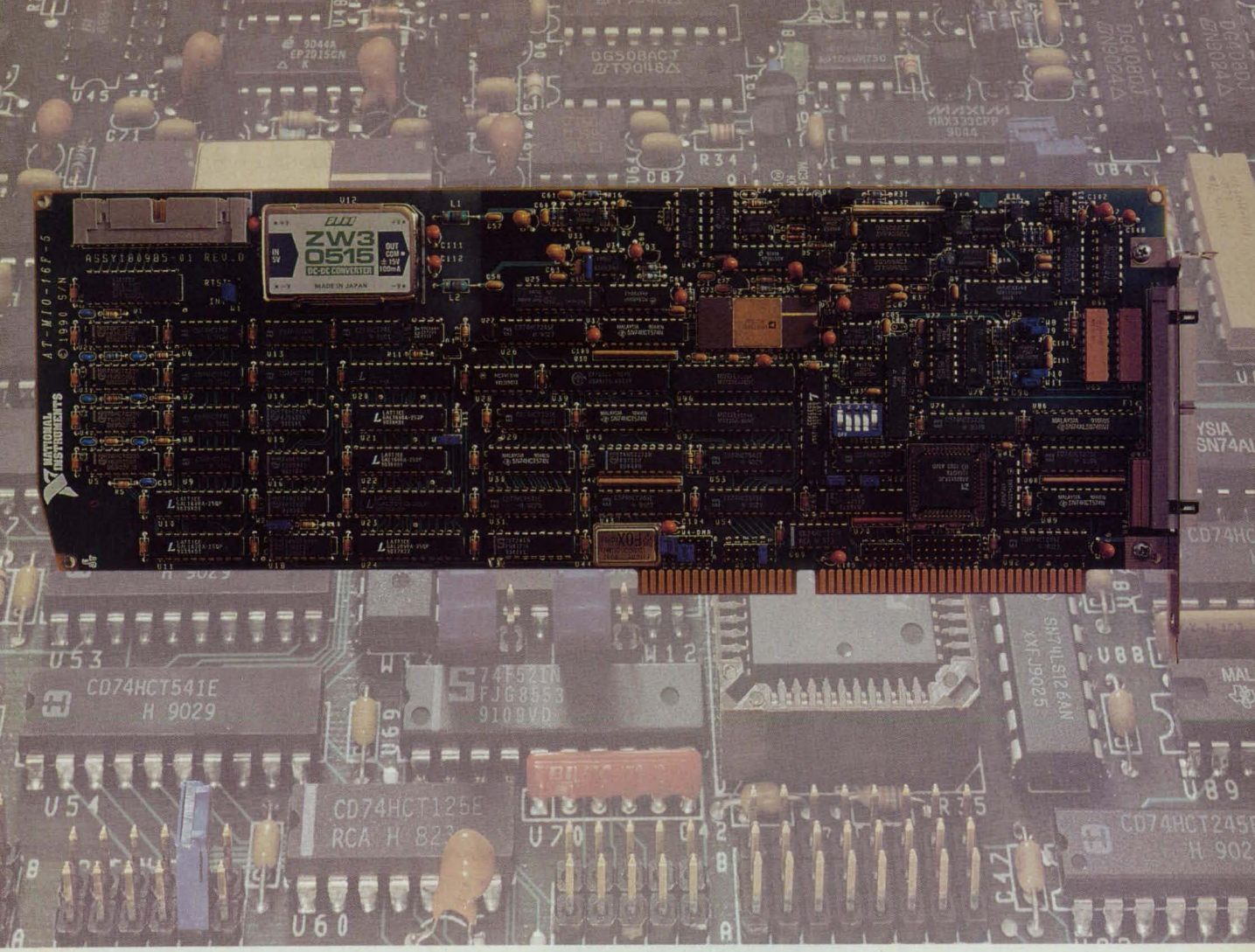
DRC® DYNAMICS RESEARCH CORPORATION



AdaMAT. The code word for quality Ada.

Dynamics Research Corporation, 60 Frontage Road, Andover, MA 01810

For More Information Circle No. 323



EXCELLENCE

Setting the New Standard in PC Data Acquisition

It takes a serious commitment to quality to deliver data acquisition boards that reliably meet the most demanding specifications. The National Instruments AT-MIO-16F-5 board creates a new standard in excellence with features not found on typical data acquisition boards. Most data acquisition boards have degraded accuracy at high sampling rates and high gains, due to instrumentation amplifier settling time. The AT-MIO-16F-5 does not.

The AT-MIO-16F-5 is shipped with NI-DAQ™ driver software for Microsoft Windows and DOS, and DAQWare™ getting-started software.

The AT-MIO-16F-5 can also be programmed with LabWindows application software.

Other features of the AT-MIO-16F-5 include:

- 200 ksamples/sec sampling rate
- Instrumentation amplifier that settles at all gains and rates
- 12-bit resolution
- Software-configurable analog input
- True self-calibration
- Dither generator for extended resolution
- RTSI® bus for multiboard synchronization

The AT-MIO-16F-5 is one of the many plug-in data acquisition boards from National Instruments. With our **free DAQ Designer**™ system configuration software tool, you can easily determine the best plug-in boards, signal conditioning products, and software for your specific application.

NATIONAL INSTRUMENTS®
The Software is the Instrument®

6504 Bridge Point Parkway
Austin, TX 78730-5039
Fax: (512) 794-8411

For more information on the AT-MIO-16F-5 and your free copy of DAQ Designer, call us.
(512) 794-0100 or (800) 433-3488 (U.S. and Canada)

AUSTRALIA 03 879 9422 • BELGIUM 02 757 00 20 • CANADA 519 622 9310 • DENMARK 45 76 73 22 • FRANCE 1 48 65 33 70 • GERMANY 089 714 50 93
ITALY 02 48301892 • JAPAN 03 3788 1921 • NETHERLANDS 01720 45761 • NORWAY 03 846866 • SPAIN 91 896 0675 • SWEDEN 08 984970 • SWITZERLAND 056 45 58 80 • U.K. 0635 523545

For More Information Circle No. 681

Finally...True Paperless Strip Chart Recording

If you use multiple 8-channel recorders, now get MORE for LESS with a VISIDAQ Video Strip Chart Recorder.

Visidaq™

MORE because:

- you can display data in multiple formats with one system; strip chart, X-Y, or X-Y, Y plot and alphanumeric;
- VISIDAQ increases productivity by automating your data recording, measurement, interpretation and report producing process;
- you can store the equivalent of up to 45 rolls of 275-foot strip chart paper on low cost computer media. Even *removable* hard disks for your secure projects!

LESS because:

- you can replace up to eight (8) synchronized paper strip chart recorders with one 64-channel VISIDAQ;
- VISIDAQ helps you eliminate time spent on tedious error-prone manual measurements;
- you now print only the specific report data you need, on command, so you use and store less paper.

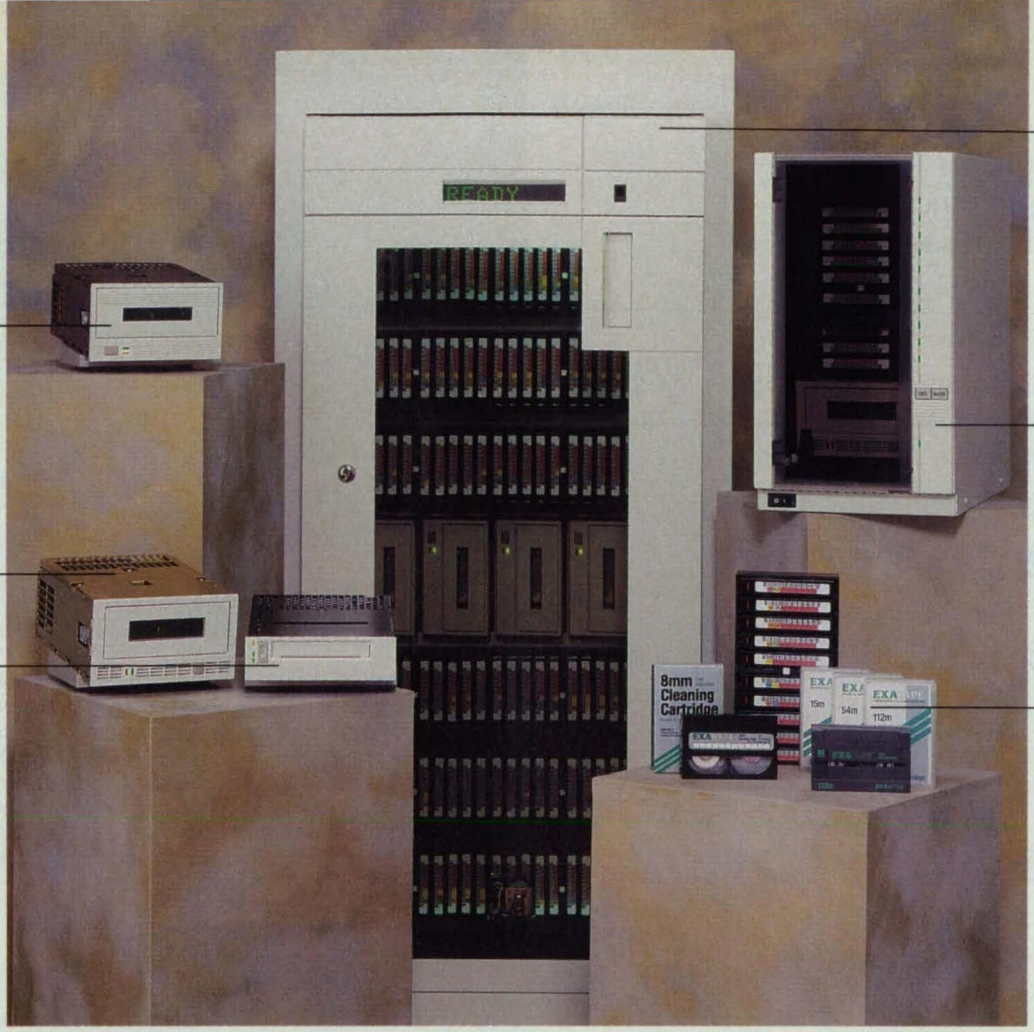
With VISIDAQ, LESS is now profitably MORE. MORE capabilities with LESS equipment **at 1/3 the cost.**

Powerful Turnkey Video Recording Systems... Now Available In 3 Models.
6400 Series - 16-64 Channels
3200 Series - 16-32 Channels
1600 Series - 8-16 Channels

For More Information Circle No. 483

Electronic Associates, Inc.
185 Monmouth Parkway, West Long Branch, NJ 07764-9989 (908) 229-1100
Toll Free: 1-800-631-4198 Fax: 1-(908)-229-1329

Call Mark Ellsworth at **1-800-631-4198** to find out how VISIDAQ can speed your move out of the paper generation.



EXB-120 CHS
580 Gigabytes

EXB-8500
5.0 Gigabytes

EXB-10 CHS
50 Gigabytes

EXB-8200
2.5 Gigabytes

EXB-8205
2.5 Gigabytes

8mm Supplies
Data Cartridges
Cleaning Cartridges
Cartridge Holders

WE CREATED OUR FAMILY SO YOU CAN SPEND MORE TIME WITH YOURS.

Our family of high-capacity 8mm data storage solutions means less time storing data and more time for yourself.

Whether it is simply backing up your workstation or accessing near-online network data bases, EXABYTE's 8mm cartridge tape subsystems and cartridge handling subsystems feature native data capacities from 2.5 gigabytes to 580 gigabytes.

So from high-end PCs to super computers, EXABYTE has the right 8mm data storage solution. For more information, call the regional office nearest you or **1-800-EXABYTE.**

And remember. We created our family so you can spend more time with yours.

EXABYTE®
THE CAPACITY TO SUCCEED

For More Information Circle No. 563

Eastern U.S. (407) 352-5622, Ext. 82
Central U.S. and Canada (708) 953-8665
Western U.S. (408) 370-6107
Europe (Amsterdam) 31-3403-51347

EXABYTE Corporation 1685 38th Street Boulder, CO 80301

NASA Tech Briefs
Transferring Technology to Industry and Government

May 1992
Volume 16 Number 5

ABP BPA

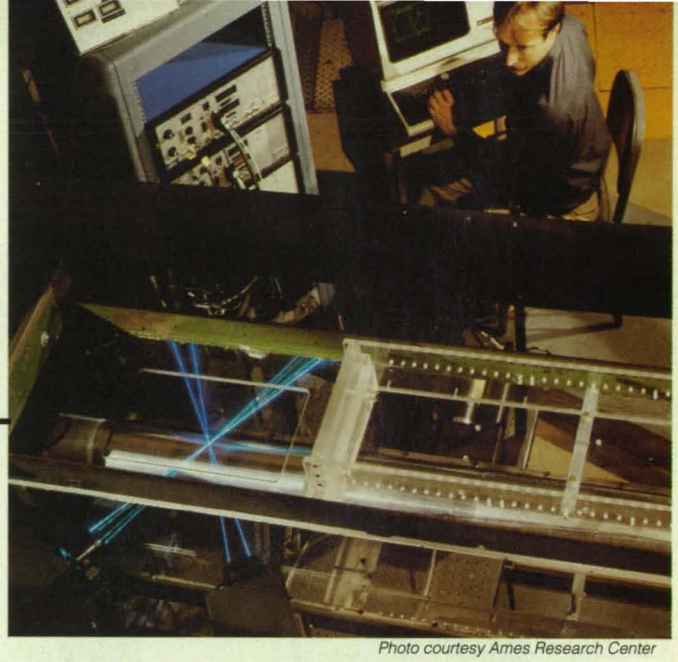


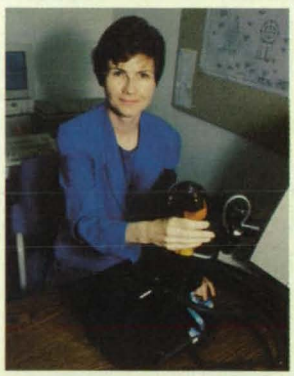
Photo courtesy Ames Research Center

NASA and the U.S. Navy are conducting experiments to measure the effects of adverse pressure gradient on three-dimensional turbulent boundary-layer flow, in hopes of improving predictive techniques for lift and drag on aerodynamic and hydrodynamic vehicles. In the experiment shown above, three-dimensional laser Doppler velocimetry is being employed within a wind tunnel to study the flow field along and around a cylindrical model. See the tech brief on page 84.

SPECIAL FEATURE

TECHNICAL SECTION

DEPARTMENTS



On The Cover: Photo montage depicts the driver's view from the cockpit of a future Mars Roving Utility Vehicle. The control station includes a force-reflecting control stick (lower right) for operating crane or boom-type attachments. Force reflection from the control stick would give the astronaut the sense of "feeling" his digging tool being moved into and out of the Martian soil. This technology offers a broad range of applications in space and on Earth for hands-on and remote operation of machines. Turn to page 12.
(Photo courtesy Cybernet Systems Corp.)

A new invention developed by this researcher's firm under NASA sponsorship puts engineers in closer "touch" with their CAD creations. Turn to Mission Accomplished, page 12.
Photo courtesy Cybernet Systems Inc.

NASA Tech Briefs, ISSN 0145-319X, USPS 750-070, copyright © 1992 in U.S., is published monthly by Associated Business Publications Co., Ltd., 41 E. 42nd St., New York, NY 10017-5391. The copyrighted information does not include the (U. S. rights to) individual tech briefs which are supplied by NASA. Editorial, sales, production and circulation offices at 41 East 42nd Street, New York, NY 10017-5391. Subscription for non-qualified subscribers in the U.S. , Panama Canal Zone, and Puerto Rico, $75.00 for 1 year; $125.00 for 2 years; $200.00 for 3 years. Single copies $10.00. Foreign subscriptions one-year U.S. Funds $150.00. Remit by check, draft, postal, express orders or VISA, MasterCard, and American Express. Other remittances at sender's risk. Address all communications for subscriptions or circulation to NASA Tech Briefs, 41 East 42nd Street, New York, NY 10017-5391. Second-class postage paid at New York, NY and additional mailing offices.

POSTMASTER: please send address changes to NASA Tech Briefs, 41 E. 42nd Street, Suite 921, New York, NY 10017-5391.

HTBasic Is the Perfect Fit

TransEra's HTBasic combines the effortless programming of HP-style BASIC with advanced application development system features such as scientific instrument control, data analysis, and graphic presentation.

Powerful facilities for data acquisition and IEEE-488.2/RS-232 instrument control, COMPLEX arithmetic, CSUB capabilities, matrix mathematics, and complete HP-style graphics make HTBasic the answer for all levels of users.

TransEra's 32-bit Compiler for HTBasic routines gives access to significant performance increases in high-speed math calculations. And a full library of pre-compiled subroutines for FFT's, curve-fitting, waveform analysis, and digital filtering/windowing can make developing your application much less puzzling.

With HTBasic, your PC becomes a scientific workstation that is compatible with the HP9000 Series 200/300. In fact, the transfer utility included with HTBasic lets you port your current HP Basic programs to the PC and run them with little or no modification while adding all of the functionality of industry standard PC hardware and software. You can share data with spreadsheet and database programs, use standard graphics displays, output devices, even networks.

For Speed, Power, Flexibility, and Functionality, HTBasic for the PC is the perfect fit.

Call or write today.

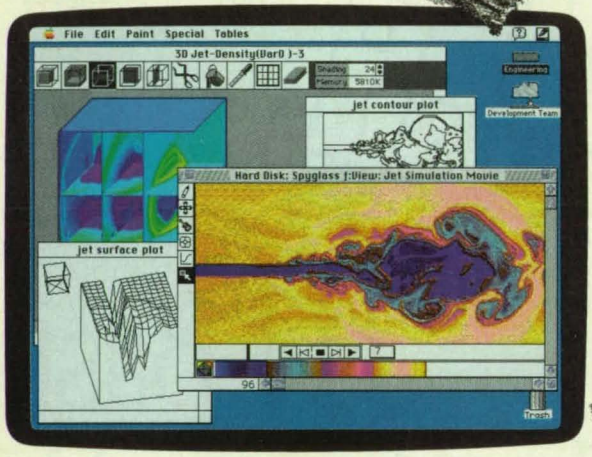
TransEra

Engineering Excellence for 15 Years™

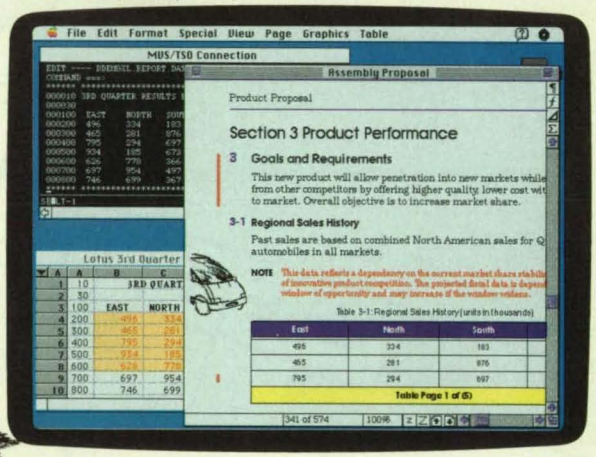
3707 N. Canyon Road, Provo, UT 84604 • (801) 224-6550, FAX (801) 224-0355

For More Information Circle No. 474

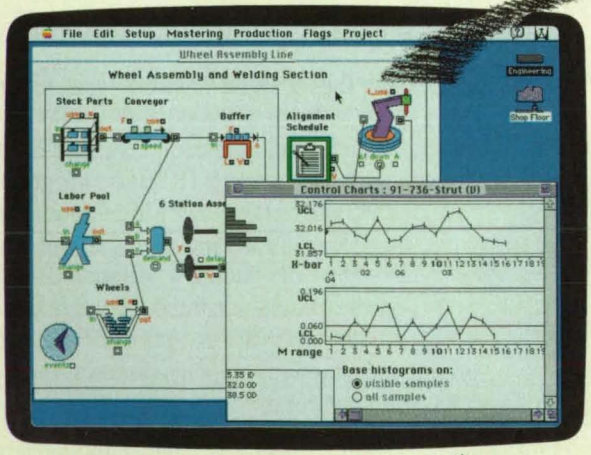
Building Macintosh builds quality



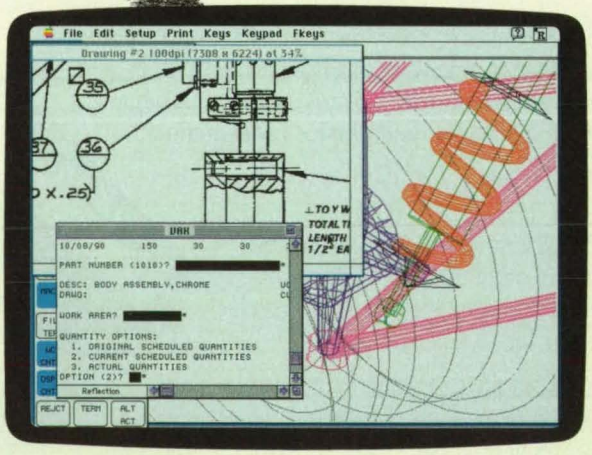
Engineering looks at R&D



Engineering looks at Marketing



Engineering looks at Manufacturing



Manufacturing looks at Engineering

(SCREEN, UPPER LEFT) Engineering and scientific data visualized with Spyglass software. (SCREEN, UPPER RIGHT) Shown in background: sales history is captured locally on the Macintosh from an IBM host using 3270 terminal emulation, and then cut and paste into Lotus 1-2-3 for Macintosh. Shown in foreground: data is placed in a table format using FrameMaker, a technical publishing package by Frame Technology. (SCREEN, BOTTOM LEFT) In background: Extend by Imagine That simulates the processes on the shop floor. In foreground: Shop floor data is analyzed using Applied Stat by Applied Statistics, a statistical process control program. (SCREEN, BOTTOM RIGHT) In background: ACCESS-150, a terminal emulation program by EDS, allows the Macintosh to front-end Unigraphics software. Also, Optix, a document management package from Blueridge Technologies, shows a scanned working drawing. In foreground: MANMAN, an integrated MRP II system from Ask Computer Systems, Inc., is running on a remote VAX host.

into the process into the result.

These days, it seems as though you constantly hear terms like "total quality management," "design for manufacturing," and "concurrent engineering."

All of which point to the underlying concerns in industry today: how to best integrate resources in order to reduce time to market and production costs, while raising overall product quality.

At Apple®, we've been focusing on the quality issue for a long time—and know that improving quality requires improved integration. That's why the Apple® Macintosh® computer is so adept at helping people work better—individually and in teams throughout an organization.

Macintosh is the ideal platform for integrating the people, information, and technology that drive manufacturing productivity—no matter what kind of computing environment they operate in. It connects to everything from personal computers to UNIX workstations to IBM and DEC hosts.

Macintosh also supports industry data standards such as IGES and DXF, as well as the X-Window protocol through Apple's MacX.™ And it provides SQL-based data access through Apple's Data Access Language (DAL). A complete implementation of UNIX System V 2.2 for Macintosh, A/UX® 3.0, even lets you run a variety of UNIX applications.

All of which make it easier to achieve applications and data integration within your organization. In other words, engineering can talk to R&D, and manufacturing can share information with engineering—even if the departments are running on different networks.

With Macintosh, products get to market faster because operating system features like System 7's built-in file and data sharing capabilities allow the whole team to keep in touch with the latest details—throughout the design and production process.

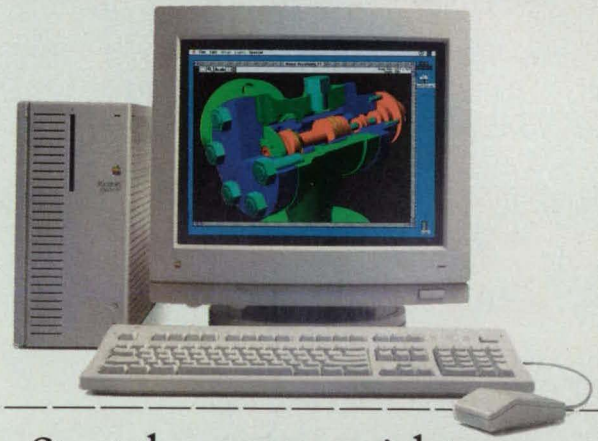
And the consistent, nonintimidating Macintosh environment can be used by everyone from designers to mechanical engineers to shop-floor operators with very little up-front training time.

Combine all these benefits with the wealth of powerful Macintosh-based applications for everything from CAD to technical documentation to shop-floor management, and you'll start seeing new levels of quality throughout your organization.

And you'll understand how the concept of teamwork really works. To understand more, send for your free "Apple Solutions for Engineering" package today.

Complete and return the coupon below. Or call us at 1-800-732-3131, ext. 924.

Apple®



Start the process right now.

Send for your free "Apple Solutions for Engineering" package, containing a videotape, product brochures, and other information on how Macintosh can help improve product quality in your organization. Complete and mail this coupon to Apple Computer, Inc., Dept. 924, 703 West Housatonic St., Pittsfield, MA 01201-9816. Offer good until September 30, 1992.

Name _____ Title _____

Company _____

Address _____

City _____ State _____ Zip _____

( ) _____

Phone

NASA Tech Briefs

Official Publication of
National Aeronautics and
Space Administration

ABP BPA

NASA Tech Briefs:

Published by ..... **Associated Business Publications**
Editor-in-Chief/Publisher ..... **Bill Schnirring**
Associate Publisher/Editor ..... **Joseph T. Pramberger**
Managing Editor ..... **R.J. Laer**
Associate Editor ..... **Sarah L. Gall**
Technical Advisor ..... **Dr. Robert E. Waterman**
Production Manager ..... **Rita Nothaft**
Traffic Manager ..... **James E. Cobb**
Art Director ..... **Pierre Granier**
Marketing Director ..... **Wayne Pierce**
Advertising Coordinator ..... **Nipa Joshi**
Telecommunications Specialist ..... **Evelyn Mars**
Reader Service Manager ..... **Sylvia Valentin**

Briefs & Supporting Literature:
Provided to National Aeronautics and Space Administration by
International Computers & Telecommunications, Inc.,
NY, NY with assistance from **Logical Technical Services**, NY, NY
Technical/Managing Editor ..... **Ted Selinsky**
Art Director ..... **Luis Martinez**
Administrator ..... **Elizabeth Texeira**
Chief Copy Editor ..... **Lorne Bullen**
Staff Writers/Editors ..... **Dr. James Boyd, Dr. Larry Grunberger, Dr. Theron Cole, Jordan Randjelovich, George Watson, Oden Browne**
Graphics ..... **Zinaida Gimpeleva, Vernald Gillman, Pamela Baynham, Charles Sammartano**
Editorial & Production ..... **Bill Little, Ivonne Valdes, Susan Kyu Oh, Frank Ponce**

NASA:
NASA Tech Briefs are provided by the National Aeronautics and Space Administration, Technology Utilization Division, Washington, DC:
Administrator ..... **Daniel S. Goldin**
Assistant Administrator for Commercial Programs ..... **John G. Mannix**
Deputy Assistant Administrator(Programs) ..... **Frank E. Penaranda**
Deputy Director TU Division(Publications Manager) ..... **Leonard A. Ault**
Manager, Technology Utilization Office, NASA Center
For AeroSpace Information ..... **Walter M. Heiland**

Associated Business Publications
41 East 42nd Street, Suite 921, New York, NY 10017-5391
(212) 490-3999 FAX (212) 986-7864
President ..... **Bill Schnirring**
Executive Vice President ..... **Frank Nothaft**
Vice President/Chief Operating Officer ..... **Domenic A. Mucchetti**
Operations Manager ..... **Rita Nothaft**
Controller ..... **Felecia Lahey**
Trade Show Director ..... **Wendy S. Janiel**
Systems Analyst ..... **Patrick Wolfert**

Advertising:
New York Office: (212) 490-3999 FAX (212) 986-7864

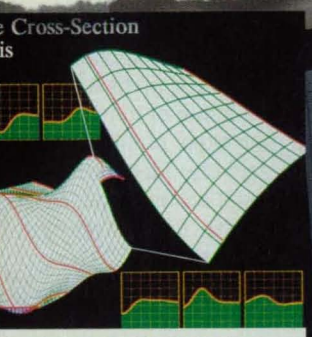
Account Executives:

NY, NJ, OH, MI ..... **Brian Clerkin** at (201) 366-2751
NJ (Area Codes 201 and 908) ..... **Debby Crane** at (201) 967-9838
PA, DE, NJ (Area Code 609) ..... **Tara Morie** at (215) 640-3118
VA, DC, MD, WV ..... **John D. Floyd, CBC** at (215) 399-3265
Eastern MA, NH, ME, RI ..... **Paul Gillespie** at (508) 429-8907; **Bill Doucette** at (508) 429-9861
Western MA, CT, VT ..... **George Watts** at (413) 253-9881
West Central, Southeast, Southwest ..... **Douglas Shaller** at (212) 490-3999
Midwest—IL, WI, MN ..... **Paul Lesher, CBC** at (312) 296-2040
Northwest—WA, OR ..... **Bill Hague** at (206) 858-7575
West Coast—CA, AZ, NV, NM, UT ..... **Stillman Group** at (310) 372-2744
for Area Codes 602/702/505/818/805: **Paul Sanacore**
for 213/619/714: **Robert D'Alexander, Tom Stillman**
for 408/415/916/209/707/801: **Ron Hall**

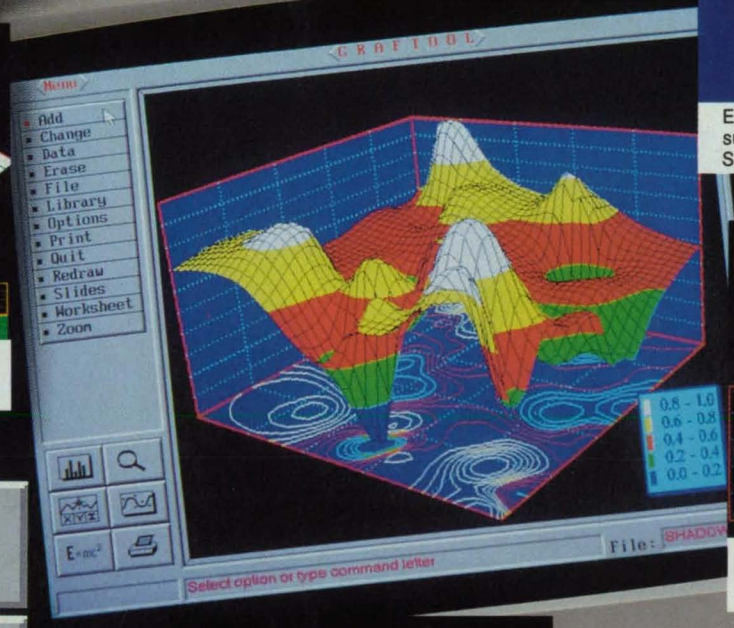
NTBM-Research Center
Account Supervisor ..... **Lourdes Del Valle**

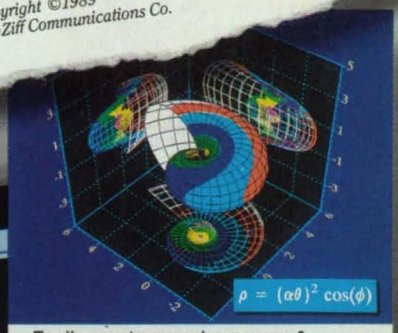
PC MAGAZINE
EDITORS' CHOICE
March 26, 1991
Graftool, Version 3.3

GRAFTOOL™
"is the best choice..." and "...delivers on all accounts."

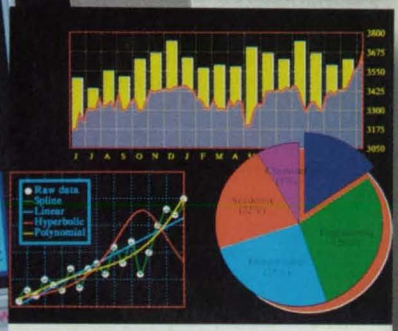


...ate contours, surfaces, and cross-...ns from random X, Y, Z points.

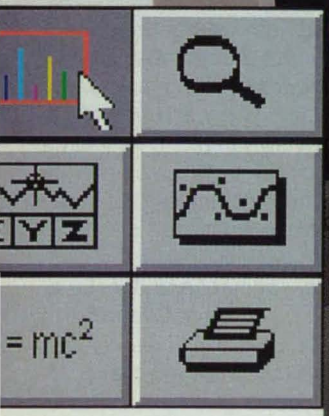




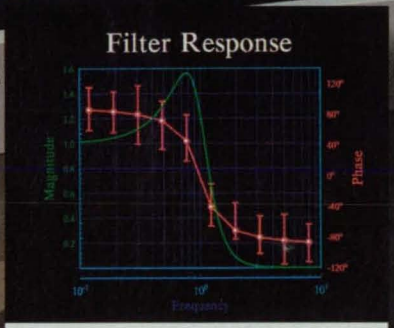
Easily create complex curves & surfaces with the graphical Formula-Solver.™



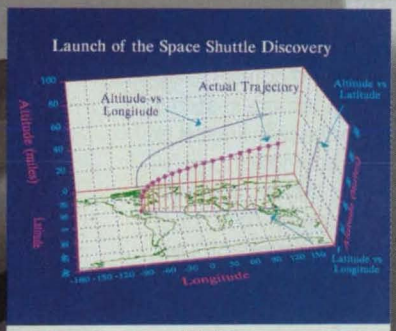
Choose from 26 graph types for business, technical, & scientific data.



...V push-button "mouse-menus" ...w easy access to frequently used ...ures.



Automate customized graph creation with pre-recorded macro & batch files.



Integrate 2-D and 3-D data on a single graph to add meaning and impact.

Presentation graphics and analysis for scientific users.

...our technical data requires more muscle ...nd sophistication than basic business ...raphics and plotting packages can ...rovide. It's simply a matter of using the ...ght tool for the job. In addition to ...ublication-quality graphics, you need ...owerful analysis tools and capabilities ...uch as Graftool's ■ Intelligent Data ...ursor™ to read out data points on curves ... surfaces ■ Linear & non-linear curve-...tting ■ Unlimited zoom & rotation ... Multiple axes in linear, log, or proba-...ility scales ■ Advanced data handling, ...llowing over 268,000,000 data points ... Powerful scientific spreadsheet which ...an directly read your Lotus or ASCII files

■ Unrestricted placement of graphs & text
■ Direct compatibility with Microsoft Word & WordPerfect.

With Graftool, all this power and flexibility purr quietly under the hood, while pop-up menus and push-buttons bring an ease of use previously unheard of in scientific software. Just "point & process" with increased productivity and greater understanding.

GRAFTOOL — the right tool for your technical solutions.

GRAFTOOL $495.

■ Interactive demo available
■ Academic discounts.

3D 3-D VISIONS

Call Toll Free for Details

1-800-729-4723

2780 Skypark Drive, Torrance, CA 90505

For More Information Circle No. 392

Mission Accomplished

Through the technology transfer process, many of the systems, methods, and products pioneered by NASA are reapplied in the private sector, obviating duplicate research and making a broad range of new products and services available to the public.

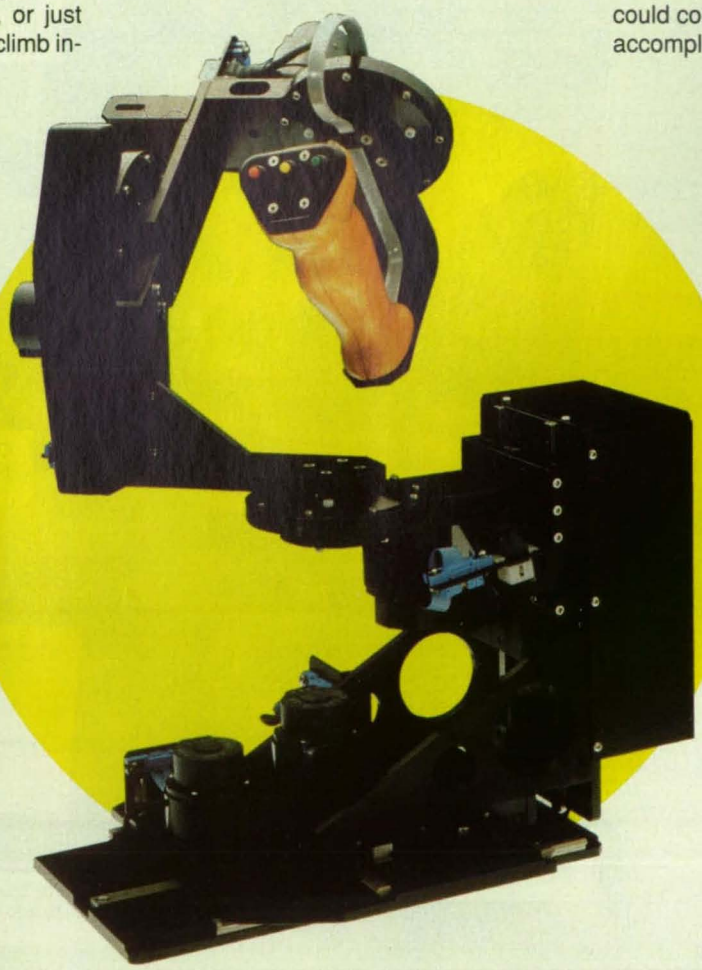
An engineer completes a computer-aided design of a bridge and would like to test its integrity. Instead of building a prototype, or just watching a simulation, he can climb into a virtual car, drive over his virtual bridge, and *feel* where the bridge is shaky.

Force reflection, the ability of a telerobotic controller to simulate to the operator's hand the forces at work in a graphical or remote environment, enables such dynamic demonstrations. Used for several decades in the nuclear energy and underwater mining industries, it is only recently available in a small, general-purpose handcontroller.

Cybernet Systems Corp., Ann Arbor, MI, has introduced the PER-Force handcontroller, a compact, backdrivable robot with a motorized control stick. While in most remote systems operator feedback is limited to mouse displacement in two dimensions or visual feedback from CRT screens, this robot moves in six degrees of freedom, three linear positions (x-, y-, and z-axis), and three attitudes (roll, pitch, and yaw). This permits its use to position a slave robot at a precise location and tool angle.

Force reflection reaches the operator through the control stick: If the slave robot walks into a wall, the operator will feel the force of the impact in his hand. This feature imparts intuitive feedback to control operations and enhances their efficiency, according to Heidi Jacobus, president of Cybernet Systems.

The PER-Force handcontroller is universal, rather than coupled to a specific robot and range of tasks, making it more attractive for space applications. NASA's Johnson Space Center (JSC) sponsored development of the handcontroller through a Small Business Innovation Research (SBIR) grant, one of 16 awarded to Cybernet Systems since its founding in 1988. Duane Johnson, an engineer at JSC, was the project's technical monitor. "NASA wanted a small and versatile handcontroller for potential use on the space station," said Johnson. "Cybernet produced a sophisticated little robot that is easily adapted to various slave robot arms."



NASA Spinoff: The PER-Force handcontroller

The handcontroller meets another of NASA's requirements: It can switch back and forth between rate mode—used to transport loads across long distances—and positional mode—for object placement and manipulation. "We wanted to develop one stick that could control any number of machines accomplishing unlimited numbers of tasks," said Ms. Jacobus.

Force reflection is generated on each of the six axes by six small, brushless DC servo motors, and enables teleoperation in environments where vision is limited, such as murky waters and underground excavation sites. Force reflection confers considerable advantages when sense of touch would be beneficial but actual touching is dangerous or impossible.

"Imagine you are trying to remotely operate a very large machine such as a crane with a small controller that lacks force reflection," said Dr. Charles Jacobus, Jr., an electrical engineer and director of new business at Cybernet. "It can't possibly move as fast as you can tell it to move. After you've given it a series of commands, this huge machine would be moving on its own as it catches up to you. Our controller tracks the crane's movements precisely, never permitting you to get ahead of it. You can actually feel the machine's limitations."

The payoff in safety and accuracy is equally evident in the field of nuclear energy, according to Mr. Jacobus. Robots commonly are employed to retrieve radioactive waste through portholes in storage bins. However, the holes are lined with plastic that could easily be ruptured by a robot's imprecise motions. "With force reflection, you can set up a virtual reality 'stop' at some margin away from the edges of the porthole to prevent your steering into them," he explained. "You can even make it grow increasingly more difficult to steer toward the edge

(continued on page 157)

Magellan program leaders were awarded the 1992 Goddard Trophy for the remarkable performance of the Hughes Aircraft Company-built synthetic aperture radar aboard the orbiting Venus Magellan spacecraft. The trophy is presented annually to individuals or groups that have contributed significantly to U.S. leadership in rocketry and astronautics. Thanks to this radar, the sole scientific instrument on Magellan, a map of Venus is nearly complete. Now in its third 8-month cycle around the planet, the Magellan radar mapper has delivered images of the Venusian surface with resolution 10 times better than any previously made. Scientists hope that by studying the surface of Earth's near-twin, they can learn more about processes that formed this planet.

To measure tropical rainfall from space, scientists will use a microwave sensor built by Hughes. This high-powered sensor, which can see through clouds, is one of several measuring instruments to be carried aboard a spacecraft built at the National Aeronautics and Space Administration's Goddard Space Flight Center. It will help scientists determine phenomena such as rain rate and distribution, cloud and soil moisture levels, land and sea surface temperatures, and sea surface wind speeds. The spacecraft will be launched in 1997 by a Japanese H-2 rocket, as part of a three-year joint mission between the U.S. and Japan.

The most powerful, technologically advanced satellites ever built for commercial mobile communications will soon be serving North America. The satellites, built by Hughes and Canada's Spar Aerospace Ltd., will each have the capacity to support 3,200 simultaneous mobile users on land or sea or in the air. The spacecraft will cover the entire United States and Canada, including Alaska, Hawaii, Puerto Rico, the Virgin Islands, and 200 miles of U.S. and Canadian coastal waters. In this joint effort, Hughes will provide the HS 601 satellite bus and Spar the communications payload.

Providing meteorological satellite data worldwide takes a concerted effort, especially on a 24-hours-a-day, seven-days-a-week basis. That's why the National Oceanic and Atmospheric Administration has turned to Hughes for software development, maintenance, and science support. Hughes will help the agency obtain, process, and disseminate images of clouds, radiation, ozone, moisture, and temperature. This data is sent to organizations throughout the world, to help them monitor and forecast various atmospheric conditions.

Hughes' commitment to cost reduction, coupled with quality improvement, helps save more than $1 million in a communications satellite program. The commitment involves constantly monitoring and measuring all phases of a program with an eye toward improving quality and reducing costs. In the HS 601 communications satellite program, Hughes recognized substantial savings by replacing time-consuming structural bonds with inexpensive aluminum clips. Other savings were achieved by replacing detailed inspection of incoming parts with verification of only the critical parameters, and by determining which departments needed to sign off on individual engineering drawings, eliminating unnecessary reviews by unaffected departments.

For more information write to: P.O. Box 80032, Los Angeles, CA 90080-0032

HUGHES

Subsidiary of GM Hughes Electronics

Now you can and not get

Introducing new RISC System/6000 POWERstation

If you're interested in open systems but don't want to suffer the slings and arrows of outrageous prices, IBM is about to hit you where you live. The RISC System/6000™ POWERstation 220 gives you more wallop for your money, while delivering a hefty 25.9 SPECmarks.™ That's compared to the SUN IPC's™ 13.4 SPECmarks and the DEC5000's™ 17.8.

Model	Entry Grayscale Workstation**	Entry 8-bit Color Workstation†
IBM 220W	$7,185	$9,995
HP 705/710	$8,415	$14,065

Scientists see stars. CASE users can start with a grayscale workstation with a paging disk for just $7,185. If it's CAD clout you're after, you can get a workstation specially outfitted for mechanical design—with 2D color graphics and 400MB of fixed disk storage—for only $9,995. All models in the POWERstation 220 series come with two expansion

*In Canada, call 1 800 465-1234. **16MB, Paging Disk, Display, Operating System, Graphical User Interface. †16MB, 400MB Disk, Display, Operating System, Graphical User Interface. IBM is a registered trademark and RISC System/6000 is a trademark of International Business Machines Corporation. SPECmark is a geometric mean of the ten SPECmark tests and is a trademark of Standard Performance Evaluation Corporation. All SPECmark figures listed are as published by their respective manufacturers. All prices listed are MSRP. Remarketer prices may vary. IPC is a trademark of Sun Microsystems, Inc. DEC5000 is a trademark of Digital Equipment Corporation. UNIX is a registered trademark of UNIX Systems Laboratories. HAGAR THE HORRIBLE Character(s) © 1992 King Features Syndicate, Inc. © 1992 IBM Corp.

get more clout, clobbered.

nd POWERservers that pack more punch for less.

slots and upgradable components. And industry-standard memory upgrades and add-ons for both are affordable, so growing won't be a pain.

Striking a blow for business. The POWERserver 220 is great for commercial UNIX® solutions, too. You can configure it as a commercial server, to give your business the speed, muscle and openness of UNIX, for only $9,715. And the POWERserver 220 is as expandable as all our other models.

IBM is in your corner. Nobody else delivers the knockout support of IBM. An IBM customer engineer can install your machines, configure your network and integrate all your systems, whether they're made by IBM or not. And IBM Credit Corporation has flexible financing packages to meet your needs. Get hit with the details. Call your IBM marketing representative or Business Partner. For literature, call 1 800 IBM-6676, ext. 769*.

And, for those who decide to shop for UNIX solutions elsewhere, a word of advice. Duck.

The RISC System/6000
For the Power Seeker.

IBM®

New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 18). NASA's patent-licensing program to encourage commercial development is described on page 18.

Eddy-Current Probes for Inspecting Graphite-Fiber Composites

E- and U-shaped magnetic cores are being developed for detecting flaws in graphite-fiber/epoxy and other composite materials reinforced by graphite fibers. The new probes are to replace earlier "pancake"-style models that were designed for inspection of materials of higher conductivity. (See page 20)

Rugged Noncontact Backshorts for Waveguides

These backshorts are easily scaled for operation at frequencies from 1 to 1,000 GHz. Unlike conventional sliding backshorts, the new ones are not vulnerable to wear, oxidation, or corrosion of the contacts. (See page 26)

Digital Feedback Control Servomotor via Fiber Optics

An optoelectronic system can control the shaft angles of up to 16 servomotors. Advantages for robotic applications include immunity to electromagnetic interference, high data rates, and compactness. (See page 32)

Experimental Optoelectronic Associative Memory

The size of the memory needed to store and process the images is reduced. Unlike its all-electronic counterparts, this memory does not rely on the precomputation and storage of an outer-product synapse matrix. (See page 32)

External Squeeze-Film Damper for Hydrostatic Bearing

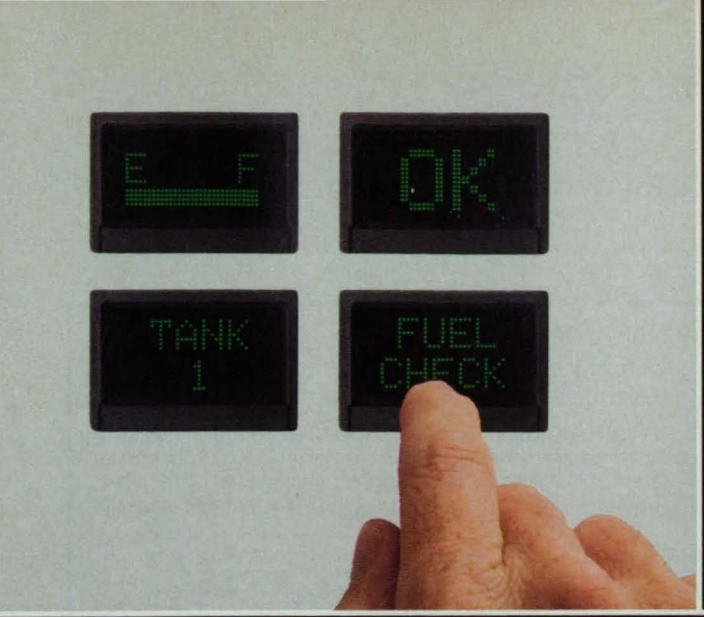
This device helps to suppress vibrations of a rapidly turning shaft in a high-pressure/high-power-density turbomachine. The damper consist of a stack of washerlike disks. (See page 80)

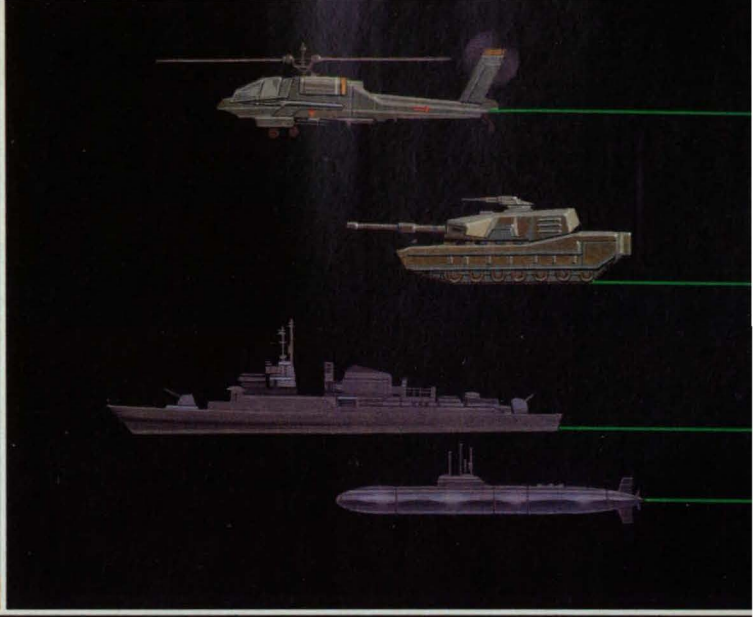
Self-Resetting Energy Absorber

Unlike conventional shock absorbers, the new absorber is compact and does not use hydraulic fluid. Its damping force can be easily adjusted. Possible applications are in industrial machinery, automobile bumpers and suspensions, and parachute lanyards, among others. (See page 89)

High-Aspect-Ratio Rotating Cell-Culture Vessel

This vessel allows the exchange of nutrients and products of metabolism with minimum agitation. Cells may be grown with little of the shear stress that would otherwise damage the mammalian cells. (See page 150)





The programmable display system:

Design applications for land, sea or air.

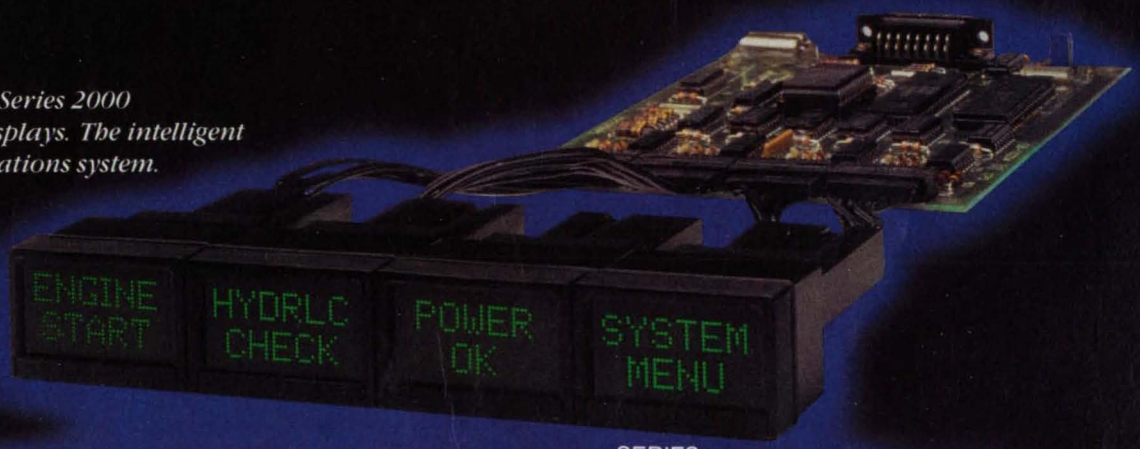
Vivisun Series 2000, now the leading programmable display pushbutton system, interfaces the operator with the host computer. The user-friendly LED dot-matrix displays can display any graphics or alpha-numerics and are available in green, red or amber. They can efficiently guide the operator through any complex sequence with no errors and no wasted time.

They also simplify operator training as well as control panel design. One Vivisun Series 2000 programmable display system can do the work of 50 or more dedicated switches. In short, Vivisun Series 2000 gives the design engineer more control over the design.

Contact us today.

AEROSPACE OPTICS INC.
3201 Sandy Lane, Fort Worth, Texas 76112
(817) 451-1141 • Telex 75-8461 • Fax (817) 654-3405

Vivisun Series 2000 programmable displays. The intelligent communications system.



SERIES

VIVISUN 2000™

HOW YOU CAN BENEFIT FROM NASA's TECHNOLOGY UTILIZATION SERVICES

If you're a regular reader of TECH BRIEFS, then you're already making use of one of the low-and no-cost services provided by NASA's Technology Utilization (TU) Network. But a TECH BRIEFS subscription represents only a fraction of the technical information and applications/engineering services offered by the TU Network as a whole. In fact, when all of the components of NASA's Technology Utilization Network are considered, TECH BRIEFS represents the proverbial tip of the iceberg.

We've outlined below NASA's TU Network—named the participants, described their services, and listed the individuals you can contact for more information relating to your specific needs. We encourage you to make use of the information, access, and applications services offered by NASA's Technology Utilization Network.

How You Can Access Technology Transfer Services At NASA Field Centers:

Technology Utilization Officers & Patent Counsels—Each NASA Field Center has a Technology Utilization Officer (TUO) and a Patent Counsel to facilitate technology transfer between NASA and the private sector.

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP). If a TSP is not available, you can contact the Technology Utilization Officer at the NASA Field Center that sponsored the research. He can arrange for assistance in applying the technology by putting you in touch with the people who developed it. If you want information about the patent status of a technology or are interested in licensing a NASA invention, contact the Patent Counsel at the NASA Field Center that sponsored the research. Refer to the NASA reference number at the end of the Tech Brief.

Ames Research Ctr.
Technology Utilization Officer:Geoffrey S. Lee
Mail Code 223-3
Moffett Field, CA 94035
(415) 604-4044
Patent Counsel:
Darrell G. Brekke
Mail Code 200-11
Moffett Field, CA 94035
(415) 604-5104

Lewis Research Center
Technology Utilization Officer: Anthony F. Ratajczak
Mail Stop 7-3
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5568
Patent Counsel:
Gene E. Shook
Mail Code LE-LAW
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-5753

John C. Stennis Space Center
Technology Utilization Officer: Robert Barlow
Code HA-30
Stennis Space Center, MS 39529
(601) 688-2042

John F. Kennedy Space Center
Technology Utilization Officer: James A. Aliberti
Mail Stop PT-PAT-A
Kennedy Space Center, FL 32899
(407) 867-3353
Patent Counsel:
Bill Sheehan
Mail Code PT-PAT
Kennedy Space Center, FL 32899
(407) 867-2544

Langley Research Ctr.
Technology Utilization Officer: Joseph J. Mathis, Jr.
Head, TU & AO Office
Mail Stop 200
Hampton, VA 23665-5225
(804) 864-2484
Patent Counsel:
Dr. George F. Helfrich
Mail Stop 143
Hampton, VA 23665-5225
(804) 864-3221

Goddard Space Flight Center
Technology Utilization Officer: Dr. George Alcorn
Mail Code 702
Greenbelt, MD 20771
(301) 286-5810
Patent Counsel:
R. Dennis Marchant
Mail Code 204
Greenbelt, MD 20771
(301) 286-7351

Jet Propulsion Lab.
NASA Resident Office
Technology Utilization Officer: Arif Husain
Mail Stop 180-801D
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4862
Patent Counsel:
Thomas H. Jones
Mail Code 180-801G
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-5179
Technology Utilization Mgr. for JPL: Dr. Norman L. Chalfin
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

George C. Marshall Space Flight Center
Technology Utilization Officer: Ismail Akbay
Code AT01
Marshall Space Flight Center,
AL 35812
(205) 544-2223
Patent Counsel:
Robert L. Broad, Jr.
Mail Code CC01
Marshall Space Flight Center,
AL 35812
(205) 544-0021

Lyndon B. Johnson Space Center
Technology Utilization Officer: Dean C. Glenn
Mail Code IC-4
Houston, TX 77058
(713) 483-3809
Patent Counsel:
Edward K. Fein
Mail Code AL3
Houston, TX 77058
(713) 483-4871

NASA Headquarters
Technology Utilization Officer: Leonard A. Ault
Code CU
Washington, DC 20546
(703) 557-5598
Assistant General Counsel for Patent Matters: Robert F. Kempf, Code GP
Washington, DC 20546
(202) 453-2424

How You Can Utilize **NASA's Regional Technology Transfer Centers (RTTCs)** — A nationwide network offering a broad range of technical services, including computerized access to over 100 million documents worldwide.

You can contact NASA's network of RTTCs for assistance in solving a specific technical problem or meeting your information needs. The "user friendly" RTTCs are staffed by technology transfer experts who provide computerized information retrieval from one of the world's largest banks of technical data. Data bases, ranging from NASA's own data base to Chemical Abstracts and INSPEC, are accessible through the six RTTCs located throughout the nation. The RTTCs also offer technical consultation services and/or linkage with other experts in the field. You can obtain more information about these services by calling or writing the nearest RTTC. User fees are charged for information services.

REGIONAL TECHNOLOGY TRANSFER CENTERS (RTTCs)

RTTC Directors

NORTHEAST
Dr. William Gasko
Center tor Technology Commercialization, Inc.
Massachusetts Technology Park
100 North Drive
Westborough, MA 01581
(508) 870-0042

MID-ATLANTIC
Ms. Lani S. Hummel
University of Pittsburgh
823 William Pitt Union
Pittsburgh, PA 15260
(412) 648-7000
(800) 257-2725 (toll-free US)

SOUTHEAST
Mr. J. Ronald Thornton
Southern Technology Application Center
University of Florida
College of Eng.
Box 24
One Progress Boulevard
Alachua, FL 32615
(904) 462-3913
(800) 354-4832 (FL only)
(800) 225-0308 (toll-free US)

MID-CONTINENT
Mr. Gary Sera
Texas Engineering Experiment Station
Texas A&M University System
237 WERC Collge Station,
Texas 77843-3401
409-845-8762
800-548-1536 (toll-free US)

MID-WEST
Dr. Joseph W. Ray
Great Lakes Industrial Technology Center
25000 Great Northern Corporate Center
Suite 450
Cleveland, OH 44070-5310
(216) 734-0094

FAR-WEST
Mr. Robert Stark
Technology Transfer Center
University of Southern California
3716 South Hope Street,
Suite 200
Los Angeles, CA 90007-4344
(213) 743-6132
(800) 642-2872 (CA only)
(800) 872-7477 (toll-free US)

If you are interested in information, applications, research, training, and services relating to satellite and aerial data for Earth resources, contact NASA's transfer point for earth observing technology: **Technology Application Center, University of New Mexico, 2808 Central, S.E., Albuquerque, NM 87131-6031; Dr. Stan Morain, Director (505) 277-3622.**

If you represent a public sector organization with a particular need, you can contact NASA's Application Team for technology matching and problem solving assistance. Staffed by professional engineers from a variety of disciplines, the Application Team works with public sector organizations to identify and solve critical problems with existing NASA technology. **Technology Application Team, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709; *Dr. Doris Rouse, Director,* (919) 541-6980**

A Shortcut To Software: **COSMIC®**—For software developed with NASA funding, contact COSMIC, NASA's Computer Software Management and Information Center. New and updated programs are announced in the Computer Programs section. COSMIC publishes an annual software catalog. For more information call or write: **COSMIC®**, 382 East Broad Street, Athens, GA 30602 *John A. Gibson, Director,* (404) 542-3265; FAX (404) 542-4807.

If You Have a Question..**NASA Center For AeroSpace Information** can answer questions about NASA's Technology Utilization Network and its services and documents. The CASI staff supplies documents and provides referrals. Call, write or use the feedback card in this issue to contact: **NASA Center For AeroSpace Information,** Technology Utilization Office, P.O. Box 8757, Baltimore, MD 21240-0757. *Walter M. Heiland, Manager,* (410) 859-5300, Ext. 245.

If you don't think our real-time systems have taken off, consider some of the programs we've landed.

You already know the significance of the Alsys name when it comes to quality Ada. But you may not have realized that over half of our business is in—and over half of all our resources are devoted to—real-time applications. Right now Boeing, Lockheed, McDonnell Douglas, NASA, AIRBUS, European Space Agency and many others rely on us for solutions for mission and safety-critical applications. Alsys offers one of the broadest ranges of compiler products and developer tools, plus unparalleled expertise and guidance every step of the way.

If you need to reduce risk, deliver projects on time, and do both within budget, the first step is easy: send in the coupon, or call 617-270-0030. We'll rush you a handbook detailing some powerful reasons why you should consider enlisting our support. Alsys. We're serious about real-time.

Please rush me the Alsys handbook detailing your real-time capabilities.

(name) (title)

(company) (phone no.)

(address)

Alsys, Inc., 67 South Bedford Street, Burlington, MA 01803-5152, phone: 617-270-0030 fax: 617-270-6882

Alsys maintains major operations in the U.S., Sweden, France, England, Germany and Japan.

alsys TB

A Thomson–CSF company

For More Information Circle No. 477

Electronic Components and Circuits

Hardware, Techniques, and Processes

Books and Reports

Collection of Charge by Diffusion From Ion Track

Effects of ionizing radiation in a silicon electronic device are approximated by simple equations.

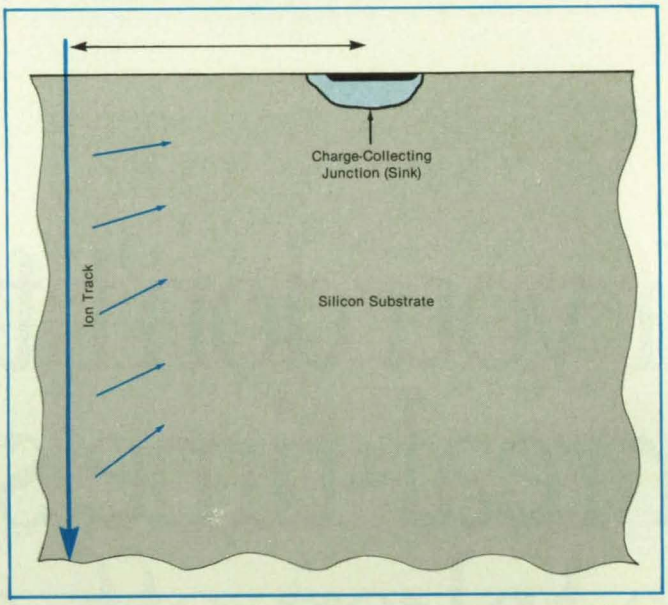
NASA's Jet Propulsion Laboratory, Pasadena, California

The collection of electric charge carriers from the track of an energetic ion through a silicon electronic device can be studied theoretically by use of a diffusion model that includes simplifying approximations. The model is intended to help in the interpretation of the results of experiments and computer simulations of single-event upsets in digital electronic circuits.

Of particular concern are the effects of (1) conductive boundaries (e.g., charge-collecting electrodes and junctions), (2) nonconductive boundaries (e.g., outer surfaces), and (3) characteristic lengths, including the length of the ion track, diffusion lengths, and the thickness of the substrate of the device. These effects impinge on the ability of a cyclotron-accelerated heavy ion (which typically penetrates the substrate to a depth of 40 μm or less) to simulate the effects of a cosmic ray (which can easily penetrate the entire substrate, typically a few tenths of a millimeter thick).

The approximate diffusion model is not meant to replace the PISCES computer program, which numerically simulates the charge-diffusion and -collection phenomena. The model is not even meant to be as accurate as PISCES is, but to yield qualitatively correct, order-of-magnitude estimates that can help avoid mistakes in the design of experiments and computer simulations.

In the model, the device is considered to consist of the substrate with a small charge-collecting junction on its upper surface (see figure) that acts as a sink. The upper surface is assumed to be electrically reflective in the sense that gradients perpendicular to this surface are zero. In this respect, the model represents the worst case for the transport of charge carriers to the junction. (In reality, an upper surface has a nonzero recombination velocity, and other sinks may act collectively to deplete the carriers.)



The **Model Represents the Transport of Charge** from the ion track to the sink by diffusion. There is assumed to be no diffusion across, or recombination at, the upper surface of the substrate. Epitaxial and buried layers are not represented in this model.

The substrate is treated as unbounded in planes parallel to the surface. The ion track is considered to be perpendicular to the surface. For an ion accelerated by a cyclotron, the depth of the substrate is assumed to be infinite. For a cosmic ray, the lower surface of the substrate is assumed to be a metal contact, and the thickness of the substrate must be taken into account. The transport of charge is assumed to be governed by a simple diffusion equation with constant coefficients, with the understanding that, in reality, diffusion coefficients vary with the densities of charge carriers.

In a computational study, the predictions of the model were found to agree well with those of PISCES in two out of three cases considered, and to agree within a factor of 2 in the third case. The model predicts a very-long-ranged transport of carriers and an increase in collected charge with the length of the ion track. When the length of the track exceeds the diffusion length, the model shows that diffusion length rather than the length of the track controls the collected charge. The model also shows that the relevant characteristic of the sink, other than its distance from the track, is its electrostatic capacitance. This implies that as the sink is made larger, without changing its shape, the collected charge increases with the linear dimension of the sink instead of its area.

This work was done by Larry D. Edmonds of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 1 on the TSP Request Card.*
NPO-18057

Eddy-Current Probes for Inspecting Graphite-Fiber Composites

Magnetic fields would be more concentrated, yielding better coupling with specimens.

Marshall Space Flight Center, Alabama

Eddy-current probes that include E-shaped and U-shaped magnetic cores are being developed for use in detecting flaws in graphite-fiber/epoxy and other composite materials that consist of electrically insulating materials reinforced by graphite

In the electronics marketplace, making the right decision isn't just important. It's critical.

You need the most accurate, up-to-date, and complete information system available.

A convenient, on-site technical library can be as close as your workstation!

• Complete • Cross-referenced
• Comprehensive • Cost-effective • Current

Rely on IHS® to help you access electronics data, industry standards and manufacturers' product literature from around the globe. With IHS you can:

- Parametrically search a worldwide database of over 1.3 million commercial and military/high reliability electronic components. Instantly link to manufacturers' datasheets, Mil Spec/QPL M-38510 and S-19500 Slash Sheets, DESC/SMD Drawings, and more!
- Access over 90% of the world's most frequently used standards including ASTM, BSI, CECC, CENELEC, CNS, ECMA, EIA, IEC, IEEE, IPC, ISHM, ISO, JIS, MOD, SAA, SAE, SANZ, SEMI, UL and more!
- Review 1.5 million+ pages of catalogs, pricing information, application notes, performance/ testing data right on your computer!
- Examine the world's most comprehensive collection of active and historical U.S. and UK military specification and defense documents, plus other U.S. and UK regulations.
- Access information in a variety of formats including: microform, hardcopy, online, magnetic tape, and CD-ROM!

Contact us today for complete details!

800-241-7824

Fax: 303-397-2747
International Sales: 303-790-0600, ext. 59 • International Fax: 303-397-2410

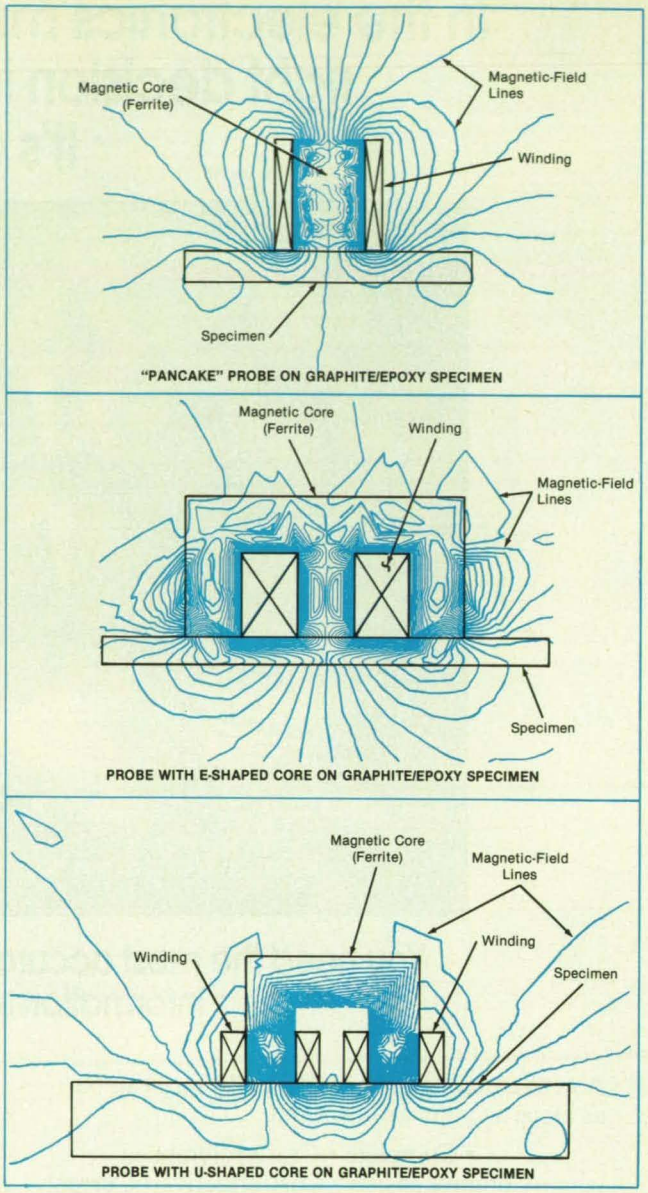
For More Information Circle No. 441

Information Handling Services®

15 Inverness Way East, Dept. 59, Englewood, Colorado 80150 USA

The company the world trusts for its technical, regulatory and business information needs.

IHS-NTB-592

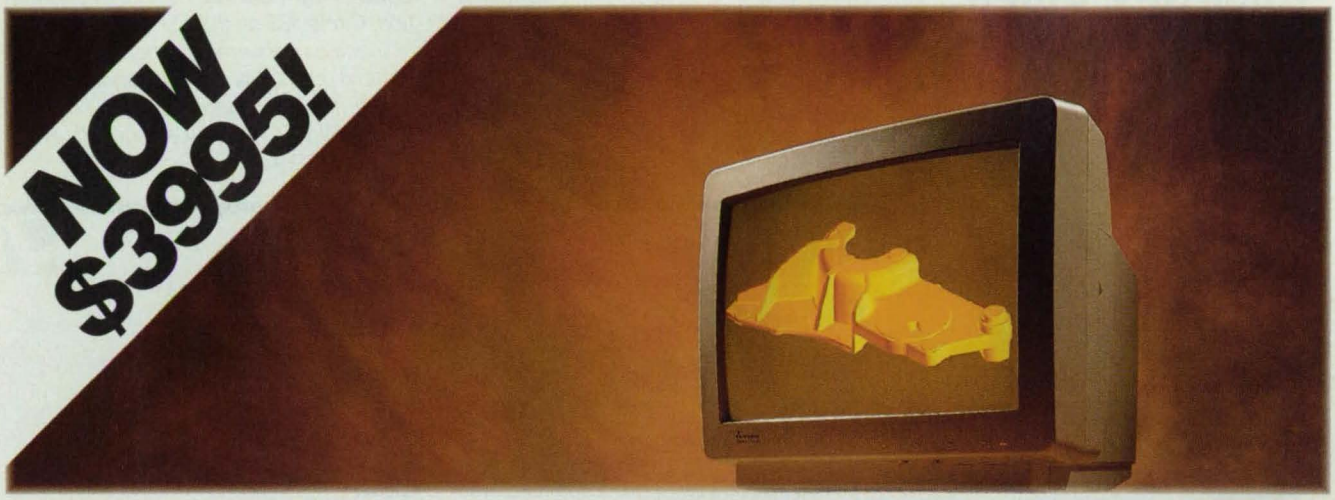


Alternating Magnetic Fields induced by three different eddy-current probes (each excited at a different frequency of the order of a few megahertz) were computed by use of a two-dimensional finite-element mathematical model. The magnetic field of the U-core probe is the one most concentrated in the specimen.

fibers. The new eddy-current probes are needed because older "pancake"-style eddy-current probes are designed for inspection of materials of higher electrical conductivity and do not effect adequate magnetic-field/eddy-current coupling with the less-conductive graphite fibers: the magnetic field of a typical "pancake" probe is spread out too much in a typical graphite-fiber composite specimen to provide optimal coupling. As shown in the figure, the magnetic field generated by a probe with an E- or U-shaped core is more concentrated in a specimen than is the magnetic field generated by a comparable "pancake" probe.

It has been proposed to incorporate E-core and/or U-core eddy-current probes into nondestructive-inspection and process-control equipment in factories that make graphite-fiber-composite parts. According to one concept, a robot would scan a probe over each part to be inspected. The end effector of the robot would include a mechanism to spin the probe when scanning a part that contains multidirectional fibers. The rotating and oscillating magnetic field would thereby be made to induce eddy-currents in fibers of all orientations, and the eddy-current signal could

The right tool for the job.



Having the right tool, like brake spring pliers or an oil filter wrench, can turn a potentially frustrating job . . . into one that is manageable and enjoyable. If your job is mechanical design, then the right tool for the job is Personal Designer® software. It provides the right combination of CAD capabilities including: ■ Comprehensive 2-D Drafting/Detailing ■ True 3-D Modeling ■ Hidden Line Removal ■ Bezier and NURB Surfaces ■ Faceted and Smooth Shaded Pictures.

With Personal Designer software, you're equipped to tackle challenging mechanical design problems. Build sizeable models (up to 64,000 entities) with complete associativity. Change the part, and all drawings, dimensions, crosshatching, and multiple views update automatically. Create drawings to ANSI, ISO, and JIS standards. Customize the user interface. And exchange data with other CAD packages via IGES or DXF.™

There's a lot more. You can fillet, sweep, and intersect complex surface geometry, and take advantage of software options for project management (PDex) and integrated 2½- and 3-axis NC programming (Personal Machinist®). To further expand your horizons, utilize the hundreds of available third party offerings. And draw on the expertise of Computervision's worldwide network of VARs.

There's a direct translator available, too. So, should you ever need Computervision's top-of-the-line CADDS® software, you can take Personal Designer data bases with you.

The bottom line: Personal Designer software is a smart buy in today's crowded marketplace. It's available for 386/486 PCs as well as the SPARCstation® workstation. And prices for 2D start at $1,995.

Get the right tool for the job, from the company that pioneered CAD/CAM.

Computervision Corporation
Personal CAD/CAM Business Unit
100 Crosby Drive, Bedford, MA 01730
Telephone (800) 248-7728 (U.S. except MA)
(617) 275-1800, ext. 4594 FAX (617) 271-0015

COMPUTERVISION

PERSONAL CAD CAM PRODUCTS

For More Information Circle No. 554

Personal Designer® 5.0

Part database courtesy of American Tool and Mold, Inc., St. Joseph, MI.

be processed into a moving time average representative of fibers of all orientations in the vicinity of the probe.

Preliminary calculations have been performed to determine design parameters for some E and U probes. For example, a probe that had overall linear dimensions of about 3 cm and self-inductance of about 3 μH could be excited at frequencies up to about 2 MHz. At the 2-MHz maximum frequency, the effective depth of penetration of the magnetic/eddy-current field in the specimen would be about 0.18 in. (about 0.5 cm).

This work was done by Gary L. Workman and Morgan Wang of the University of Alabama in Huntsville for **Marshall Space Flight Center**. *For further information, Circle 133 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 18]. Refer to MFS-26129.

Broad-Area Laser Diode With Fiber-Optic Injection

This source of infrared light is compact and rugged.

Goddard Space Flight Center, Greenbelt, Maryland

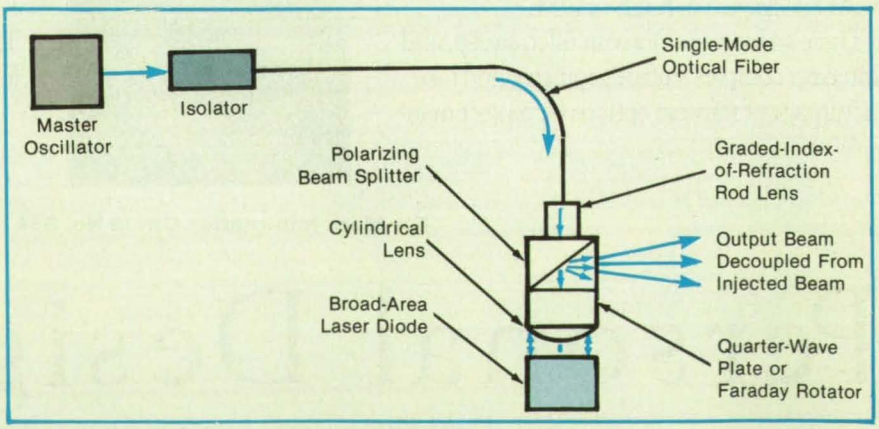
A fiber-optic injection-locked broad-area laser diode that features single-mode output via fiber-optic injection serves as a relatively compact, rugged, and high-power near-infrared source that will be useful in free-space and fiber-optic communication links. Other potential applications include use as a communication-receiver preamplifier and as a pump source for neodymium:yttrium aluminum garnet and other solid-state lasers.

In prior injection-locked laser-diode sources, the beam of light from the master oscillator has been made to propagate through a free-space optical system, which focuses the beam on the slave oscillator (the broad-area laser). Such a source is fragile and sensitive to alignment. The fiber-optic injection-locked source is relatively rugged and insensitive to alignment.

The figure illustrates schematically an experimental version of the new source. The beam from the master oscillator is sent along a single-mode optical fiber to the broad-area laser diode. A novel polarization diversity scheme is used to decouple the injected master-oscillator power from the output of the broad-area laser diode.

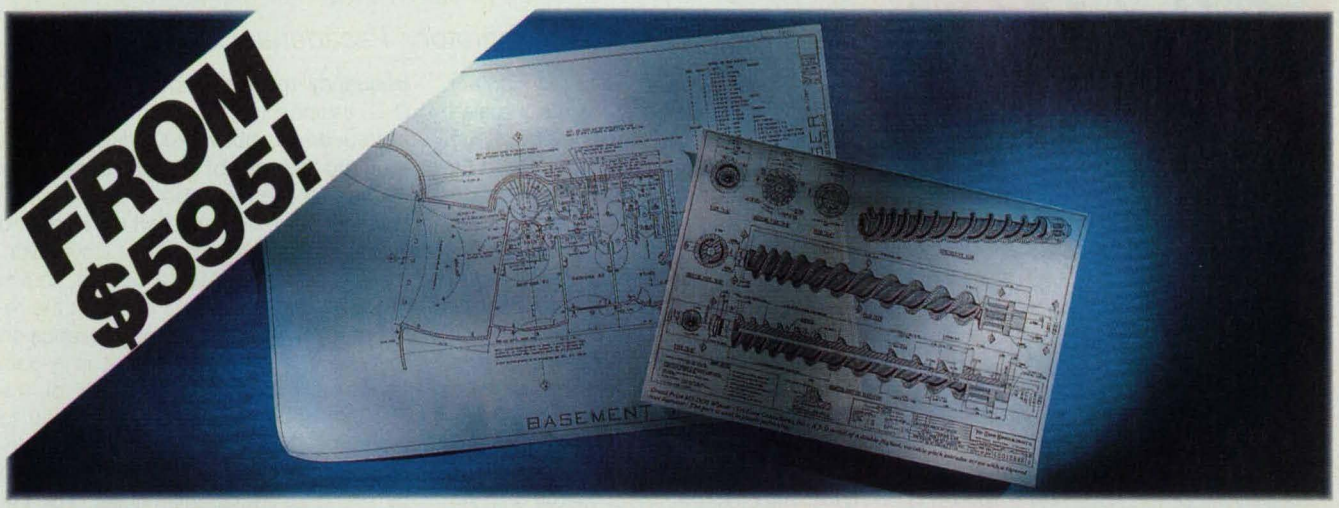
A commercially available laser-diode-to-single-mode-fiber coupler is used to launch the power from the master oscillator through a 30-dB isolator into the fiber at one end. At the other end of the fiber, the light is collimated into a 200-μm beam by a graded-index-of-refraction rod lens. This collimated beam passes through a polarizing beam splitter and a quarter-wave plate, then is focused by a cylindrical lens to a spot 200 μm long and 1 μm wide for injection into the broad-area laser diode. Output power is collimated on one axis by the cylindrical lens, passed back through the quarter-wave plate, and then reflected out from the beam splitter. Ultimately, the quarter-wave plate will be replaced by a Faraday rotator to obtain full efficiency. All of the components used in this scheme are miniature optics that can be epoxied into one rugged piece.

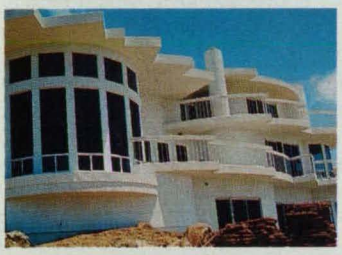
This work was done by Geoffrey Hazel, Patricia Mead, Christopher Davis of the University of Maryland, and Donald Cornwell of **Goddard Space Flight Center**. *No further documentation is available.*
GSC-13476



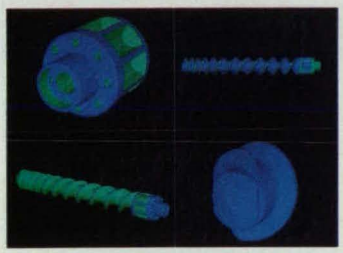
The **Single-Mode Optical Fiber** and the associated optical components are relatively insensitive to alignment and can be mounted in a compact, rugged package.

If drafting is what you do, then VersaCAD® software is what you need.





This multi-level California home spans 4,000 square feet.



More than 12,000 surfaces and 7,000 points were used to define this extruder screw.

VersaCAD software from Computervision produces high quality engineering drawings FAST. If drafting is what you do, this is the package for you.

■ **Unparalleled versatility.** Whether you're an architect, civil engineer, or mechanical designer, VersaCAD software can help. It's used daily in industries and applications from A to Z.

■ **Simple enough to learn in a day.** You need to be productive with a CAD package from day one. With VersaCAD software, you can be. And once you learn it, you'll never forget it.

■ **Sophisticated enough for demanding projects.** It may be simple to use, but VersaCAD software is solving complex engineering problems. Customers have used it to design everything from individual components to complex mechanical assemblies, from private homes to corporate headquarters, from interior and landscape designs to utility maps. Call for our latest brochure which showcases actual customer projects.

■ **Premier drafting capability.** VersaCAD software has the drafting and dimensioning features you'd expect, and then some. Alter geometry and dimensions update automatically, and vice versa. Project isometric views from orthographic views automatically. Insert a symbol into an object, such as a wall, and the geometry cuts back automatically. VersaCAD software shines in 2D, and with its 3-D visualization options you can put together eye-catching presentations.

■ **Large pool of experienced users.** 80,000 users and 1,000,000 students know VersaCAD software, so you have lots of expertise to draw upon.

■ **DOS,® UNIX,® and MAC.®** Chances are that you can run VersaCAD software on the hardware that you already have.

■ **Priced from $595.** If you're looking for leading edge drafting software that delivers a lot of value for the money, VersaCAD software is the intelligent choice.

Computervision Corporation
Personal CAD/CAM Business Unit
100 Crosby Drive, Bedford, MA 01730
Telephone (800) 248-7728 (U.S. except MA)
(617) 275-1800, ext. 4594
FAX (617) 271-0015

COMPUTERVISION

PERSONAL cad cam PRODUCTS

For More Information Circle No. 555

VersaCAD®

Private residence database courtesy of James Statser, architect, Olivenhain, CA; Extruder database courtesy of Tri-Core Consultants Inc., Hoffman Estates, IL.

Rugged Noncontact Backshorts for Waveguides

Operating frequencies can range as high as 1,000 GHz.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved adjustable noncontact backshort for a waveguide is easily scaled for operation at any frequency from 1 to 1,000 GHz. Unlike sliding backshorts of a conventional type that make contact with waveguides, the new backshort is not vulnerable to wear, oxidation, or corrosion of the contacts. It also offers important advantages over conventional noncontact backshorts.

As shown at the top of Figure 1, a conventional noncontact backshort includes a bar that has a series of low-impedance (full-thickness) sections alternating with high-impedance (partial-thickness) sections. The cross section of the bar is slightly smaller than that of the waveguide, and the bar slides smoothly in the waveguide in a sheath of insulating Mylar (or equivalent) polyethylene terephthalate. By appropriate choice of the number of sections, the impedances, and the spacing (with respect to wavelength), the effective radio-frequency impedance can be made $\ll 1\ \Omega$ — essentially a short circuit. However, at frequencies above 200 GHz or so, the required thinness of the high-impedance sections make them too difficult to fabricate and make the backshort too weak and flexible to slide snugly in the waveguide.

The new noncontact backshort, shown at the bottom of Figure 1 provides the required periodic variation of impedance on the required length scale, but in a configuration that preserves much of the strength of the bar and that is easier to fabricate. The thin high-impedance sections of the previous design are replaced by round or rectangular holes. For frequencies above 300 GHz, which require very thin waveguide sections, the backshort bar can be made of shim stock polished to the correct thickness. The holes can be drilled, milled, punched, or etched by printed-circuit-board-fabrication techniques.

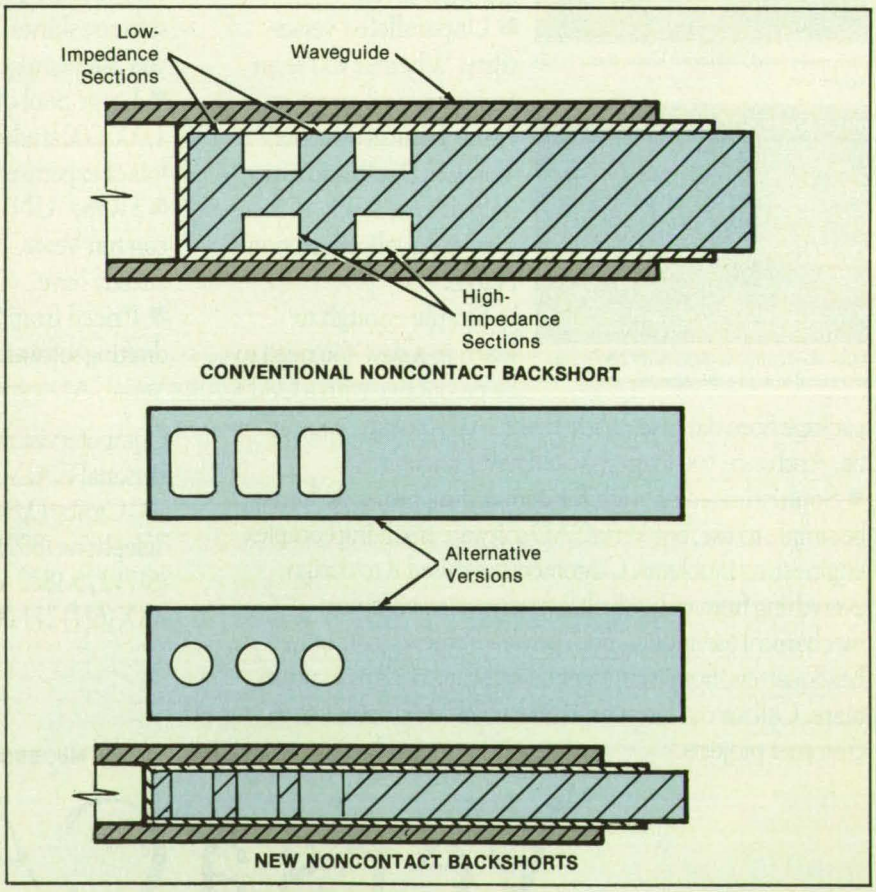
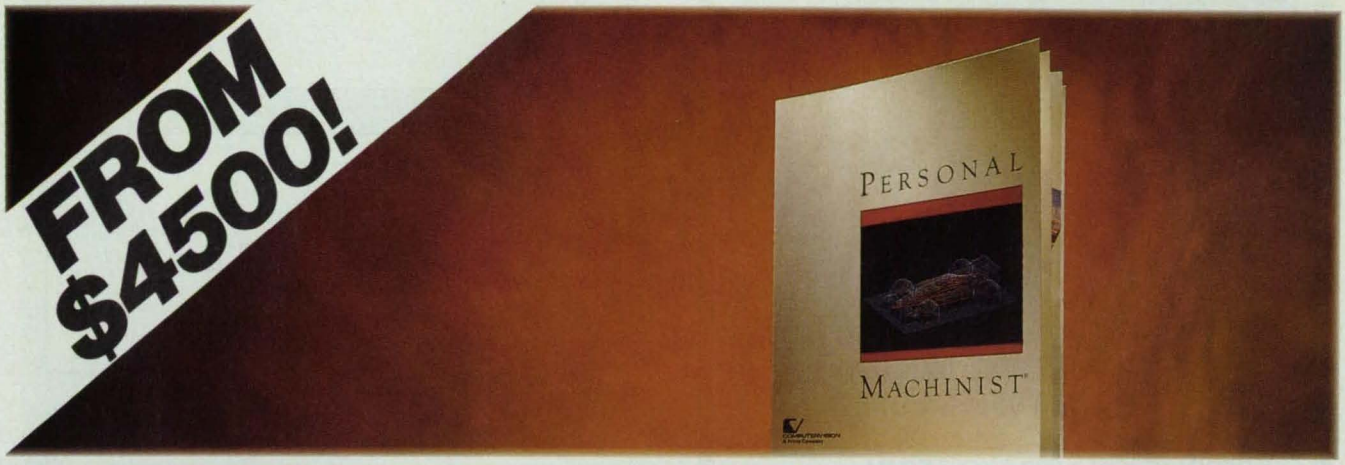
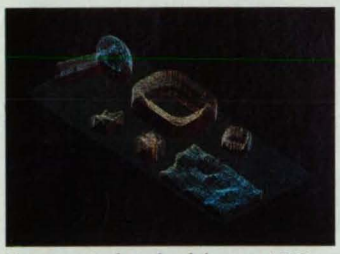


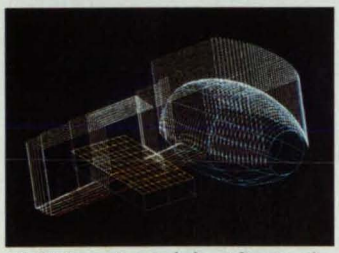
Figure 1. **Conventional and New Configurations** for noncontact sliding backshorts feature alternating high- and low-impedance sections. The improved backshorts are stronger and easier to fabricate.

The booklet is free. Choosing the wrong CAM software is costly.





Program a single tool path for up to 1,000 surfaces on a PC.



Machining options include unidirectional cutting, containment surfaces, and horizon line machining.

That's why you need to take a look at the NEW Personal Machinist® software from Computervision.® It's been re-engineered from the ground up, and sets new standards for CAM performance.

■ **A modular approach.** For starters, Personal Machinist software is totally modular. Start with the 2½ axis module. As your needs grow, add the 3-axis module for surface machining. 4- and 5-axis modules are on the way, too. Once you've learned one module, you're well on your way to mastering them all because the user interface is consistent throughout. You're dealing with a single part database, too, with no translation required.

■ **Best of class.** Personal Machinist software is the fastest and easiest to use CAM software in its class. Period. You don't have to be a computer expert. Selections are made from on-screen menus and prompts. Part geometry and tooling are displayed in full 3 D and can be examined from multiple views simultaneously. A dynamic tool display lets you preview machining operations. And the software performance is turning heads. Jobs normally expected to take hours can often be completed in minutes.

■ **Your CAD package or ours.** If you use Computervision's Personal Designer® CAD software, you can add Personal Machinist software at any time, building NC toolpaths on top of the SAME part database. If you use another CAD package, there's a version of Personal Machinist software for you, too.

■ **Write your own posts.** A universal post processor generator is included at no extra charge. Write posts for virtually any CNC machine by going through a simple on-screen question and answer session. Direct Numerical Control (DNC) utilities are included, too.

■ **Prices start at $4500.** Personal Machinist software is available for MS-DOS® PCs and the Sun® SPARCstation® workstation. With prices starting at $4500, run, don't walk, to your nearest Computervision reseller. The future of CAM is here, and Computervision has it!

Computervision Corporation
Personal CAD/CAM Business Unit
100 Crosby Drive, Bedford, MA 01730
Telephone (800) 248-7728 (U.S. except MA)
(617) 275-1800, ext. 4594
FAX (617) 271-0015

MACHINE DESIGN 91 WINNER LEADER AWARD CAD/CAM

COMPUTERVISION

PERSONAL CAD CAM PRODUCTS

Personal Machinist®

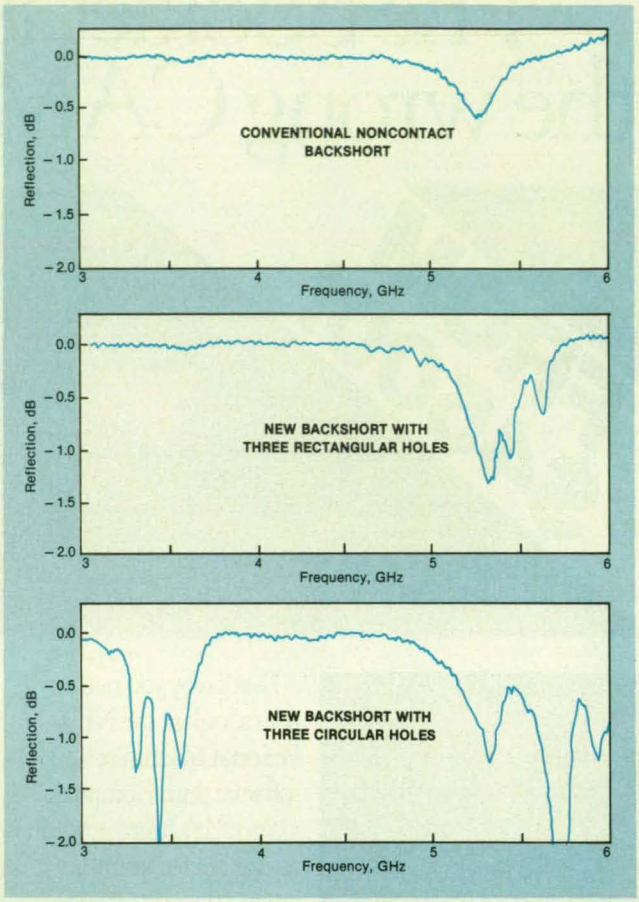


Figure 2 **Microwave Reflection Spectra** indicate that both the old and new backshorts reflect more than 95 percent of the incident signal within fairly wide frequency ranges.

Figure 2 shows the signals reflected from a conventional noncontact backshort and from two new noncontact backshorts like those shown in Figure 1. Within the frequency ranges of peak reflection, the reflection coefficients of all three backshorts exceed 0.95. Although the frequency ranges for peak reflection for the improved noncontact backshorts are smaller than those of the conventional noncontact backshorts, this is not a serious disadvantage, inasmuch as waveguide components are usually optimized for intended operating-frequency ranges narrower than these. These new backshorts will allow for the development of waveguide mixer and oscillator circuits at frequencies approaching 1,000 GHz. Such components are needed for important atmospheric and astrophysical remote-sensing programs.

This work was done by William R. McGrath of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 59 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
Director of Patents and Licensing
Mail Stop 305-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125

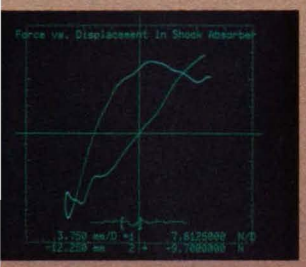
Refer to NPO-18091, volume and number of this NASA Tech Briefs *issue, and the page number.*

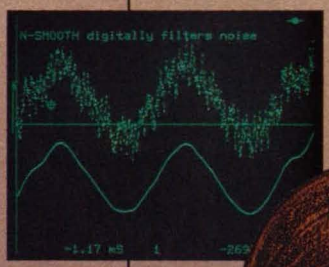
PRINCIPLES OF QUALITY MEASUREMENT: FOURTH IN A SERIES.

ACCURACY AT SPEED

Your precision measurements
on't stand still. You face exotic new
aterials to test, more intelligent
ontrollers to design and relentless
ressure to drive up quality. Work
ke this raises the speed limit for
recision – and the quality limit for
very measurement.

At Nicolet we understand the challenges you face. We make the world's most accurate oscilloscopes and transient recorders. With the resolution of a laboratory volt meter – 0.006% at 5 MS/s or 0.025% at 20 MS/s– these are instruments you need for your most demanding projects today. And *every* project tomorrow.





Five NEW models in the Nicolet series of Pro Digital Oscilloscopes establish new benchmarks for high-resolution measurements – 14 bits at 5 MS/s and 12 bits at 20 MS/s. And they all feature up to 1 megaword memory/channel to take full advantage of this remarkable breakthrough in accuracy at speed.

At Nicolet, we build instruments for measurement experts like you.

For More Information Circle No. 526

Nicolet

INSTRUMENTS OF DISCOVERY

Nicolet Measurement Instruments
Madison, Wisconsin, USA 53711-4495
608/271-3333, FAX 608/273-5061
In Canada Call: 800/387-3385

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Equivalent Circuits for ac-Impedance Analysis of Corrosion

Accuracies of several alternative models are compared.

A report presents the results of an investigation of several equivalent circuits for the ac-impedance analysis of corrosion. The basic idea of ac-impedance analysis of corrosion is straightforward: The corrosion specimen is set up as one electrode in an electrochemical cell, and the ac impedance between the specimen and electrolyte is measured as a function of frequency. The impedance-vs.-frequency data are then used to characterize the corrosion electrochemical system in terms of an equivalent circuit — usually one that consists of resistors and capacitors.

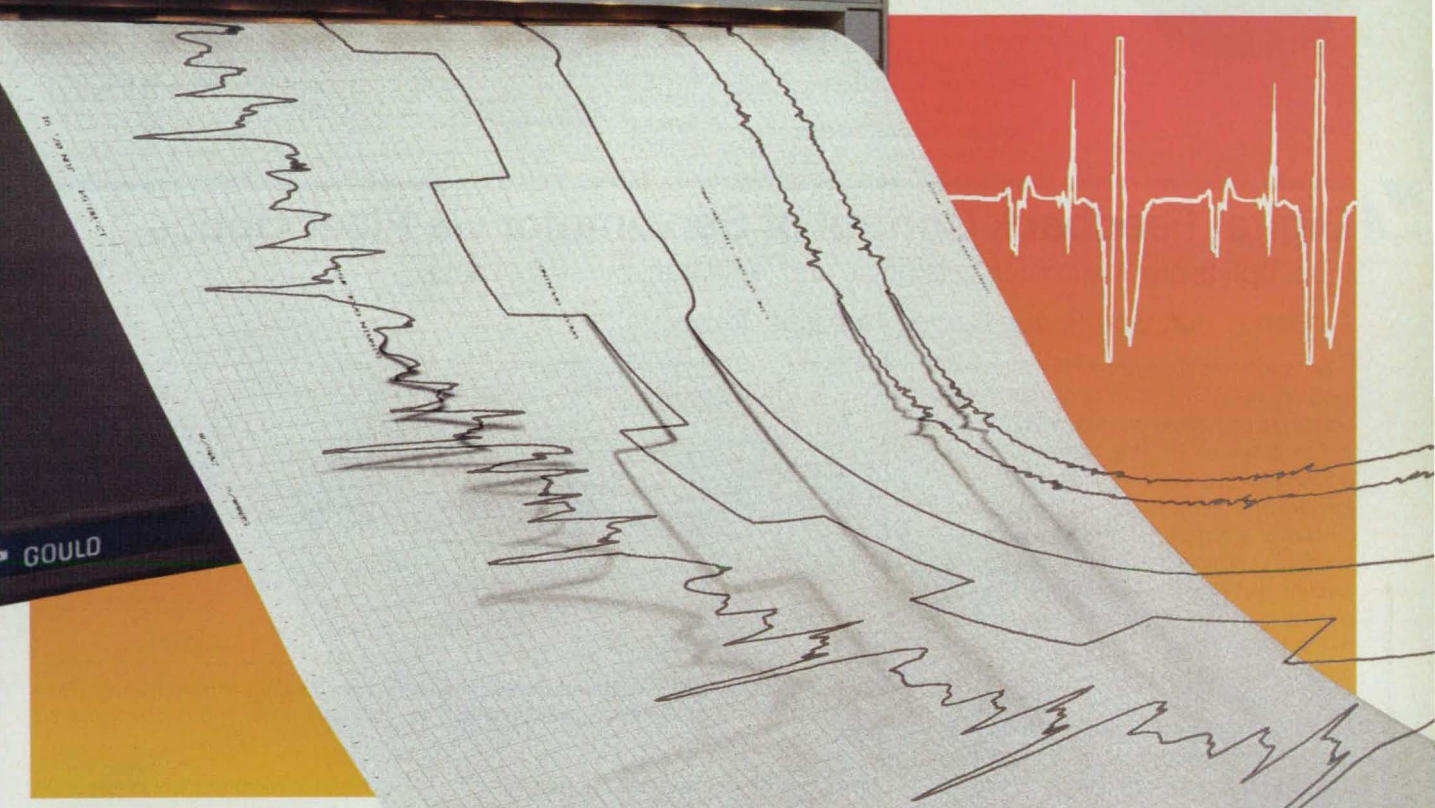
This study relied heavily on the Bode magnitude curve, which is the plot of $\log|Z|$ vs. $\log(\omega)$ (where $Z = |Z|e^{i\theta}$ = the complex impedance, $\omega = 2\pi \times$ frequency, and θ denotes the phase angle). By use of a nonlinear least-squares computer program, Bode magnitude curves obtained from corrosion measurements were fitted to the Bode magnitude curves of the chosen equivalent circuits, using the resistances and capacitances as variable parameters. Then the Bode phase curve [θ vs. $\log(\omega)$] of each equivalent circuit was calculated by use of the parameters from the least-squares fit of the Bode magnitude curve, and compared with the Bode plot of phase measurements.

Eleven resistor/capacitor equivalent-circuit mathematical models of various degrees of complexity were analyzed in this way. Three of the more-complicated models yielded the best fits with measurement data. Of these, one that involves four resistors and four capacitors in a combination of series and parallel connections was chosen as the prime model for future ac-impedance analyses of corrosion in the laboratory in which this study was conducted.

This work was done by M. D. Danford of **Marshall Space Flight Center**. *Further information may be found in NASA TM-100402 [N90-25277], "Equivalent Circuit Models for AC Impedance Data Analysis."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
MFS-27251

GOULD
Electronics



The truth comes out.

When we say the Gould TA4000 has all the features you need to get the most accurate trace available, nothing could be closer to the truth.

First, Gould signal conditioners. Not only do we offer the industry's widest selection, but also the most accurate. So no matter what your application, you always have the right answer.

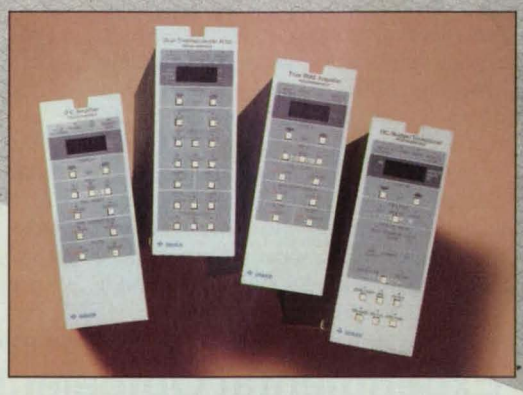
Second, the dedicated controls. Features like auto-setup and simple trace positioning make start-ups a breeze and minimize operator errors.

Then, its 15″ printhead records 8 to 24 channels in either separate or overlapping modes, with no gap in the center.

And finally, our exclusive Micropulsing® circuitry maintains brilliant contrast at all chart speeds and every signal frequency.

All this, backed by the largest sales and support organization in the recorder industry.

Call Gould today at 1-216-328-7000 or for immediate response fill out the coupon and FAX it to us today. And we'll give it to you straight.



NTB 5/92

Please ☐ Rush me a TA4000 brochure
☐ Have a Gould Sales Representative call

Name: _____

Title: _____

Company: _____

Street: _____

City: _____ State: _____ Zip: _____

Telephone: _____

Send to: Gould Inc., Test and Measurement Group, 8333 Rockside Road, Valley View, Ohio 44125. Fax: (216) 328-7400.

For More Information Circle No. 484

Electronic Systems

Hardware, Techniques, and Processes

Books and Reports

Digital Feedback Control of Servomotor via Fiber Optics

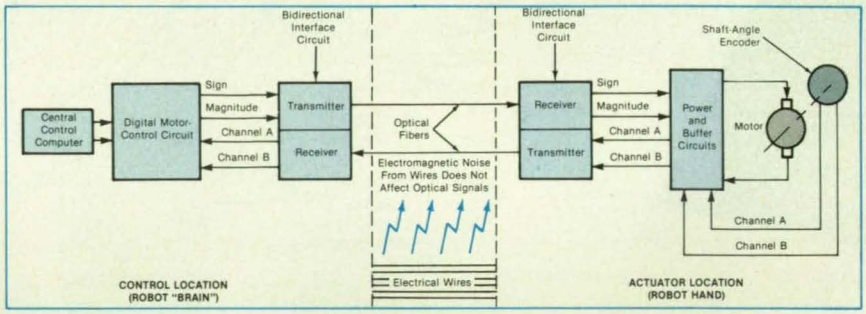
Fiber optics provide immunity to noise and rapid transmission of data.

Lyndon B. Johnson Space Center, Houston, Texas

An optoelectronic system effects closed-loop control of the shaft angles of 4 servomotors and could be expanded to control as many as 16. The system includes a full-duplex fiber-optic link that carries feedforward and feedback digital signals, possibly over a distance of many meters, between (1) commercial digital motor-control circuits that execute proportional/integral/derivative control algorithms with programmable gains (one such control circuit dedicated to each servomotor) and (2) modules that contain the motor-power-switching circuits, digital-to-analog buffer circuits for the feedforward control signals, and analog-to-digital buffer circuits for the feedback signals from the shaft-angle encoders (one such module located near, and dedicated to, each servomotor).

This is believed to be among the first uses of fiber-optic transmission to close a digital motor-control loop. Fiber-optic transmission offers the advantages of high data rates and immunity to electromagnetic noise at radio and lower frequencies. Optical fibers are compact and flexible. These features are particularly advantageous in robots, which must often function in electromagnetically noisy environments and in which it would otherwise be necessary to use many stiff, bulky wires (which could interfere with movement) to accommodate the required data rates.

The figure shows schematically the fiber-optic link and major subsystems of the control loop of one servomotor. Each digital motor-control circuit is connected to a central control computer, which programs the controller gains and provides the high-level position commands. The other inputs to the motor-control circuit are the channel A and B quadrature shaft-angle feedback signals. The outputs of the motor-control circuit include the sign of the commanded motor current and pulse-width modulation representative of the magnitude of commanded motor current.



Full-Duplex Fiber-Optic Transmission is particularly advantageous in robotic applications, in which immunity to electromagnetic interference, high data rates, and compactness are particularly desirable.

The fiber-optic link includes two optical fibers — one for feedforward, one for feedback. The ends of the fibers are connected to two identical bidirectional interface circuit boards, each containing a transmitter and a receiver. The fiber-optic link has a throughput rate of 175 MHz; at this high rate, it functions as though it were a 32-bit (8 bits for each motor-control loop) parallel link, even though the data are multiplexed into a serial bit stream for transmission. In the receiver, the bit stream is decoded to reconstruct the 8-bit pattern, and a programmable logic sequencer expands the 8-bit pattern to 32 bits and checks for errors by use of synchronizing bits.

This work was done by Reginald Dawson and Dagoberto Rodriguez of Lockheed Engineering and Sciences Co. for **Johnson Space Center**. *For further information, Circle 102 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 18]. Refer to MSC-21806.

Experimental Optoelectronic Associative Memory

The size of the memory needed to store and process images is reduced.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure illustrates schematically an experimental optoelectronic associative memory that responds to an input image by displaying one of *M* remembered images. The decision about which (if any) of the remembered images to display is made by an optoelectronic analog computation of an inner-product-like measure of resemblance between the input image and each of the remembered images. Unlike associative memories implemented as all-electronic neural networks, this memory does not rely on the precomputation and storage of an outer-product synapse matrix. Instead, the optoelectronic equivalent of this matrix is realized by storing the remembered images in two separated spatial light modulators placed in tandem. This scheme reduces the required size of the memory by an order of magnitude.

A partial input image is binarized and displayed on a liquid-crystal light valve spatial light modulator, which preprocesses the image in real time by operating in

The Choice In Space-Qualified GPS Receivers

Monarch™
GPS Spaceborne Receiver

There is a big difference between adapting a standard GPS to space, and choosing a GPS specifically engineered for space performance and endurance from the start.

That is why the GPS Spaceborne Receiver from Motorola outperforms its competitors. It is small, lightweight, highly reliable, low power, and radiation and single event upset tolerant. Engineered to meet severe spaceborne environmental conditions, including pyro-shock, vibration, and temperature cycling. Engineered from the start to perform in space.

As an option, Motorola also offers precise positioning service, which includes selective availability and anti-spoof features. The Motorola GPS receiver also offers capabilities for continuous and simultaneous tracking of all satellites in view. Other configurations permit multiple antenna operations, including attitude control.

You have a choice. Take a ground use GPS unit and go through the pains of qualifying it for space use - or pick up the phone and call Motorola.

Engineering Quality Space Communications

For information on the space-ready Motorola GPS, call

602-732-7104

or write P.O. Box 2606 Scottsdale, AZ 85252

MOTOROLA

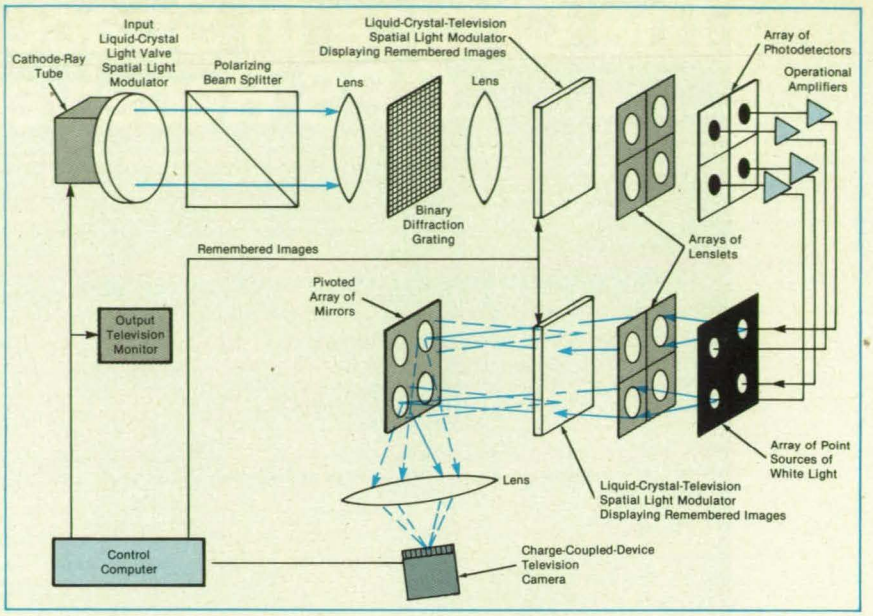
SGLS S-BAND TRANSPONDERS • GPS • TDRSS • NASA STANDARD TRANSPONDERS • COMMUNICATION PROCESSORS • RF SUBSYSTEMS • SIGNAL ANALYSIS/SPECIALIZED RECEIVERS • GROUND SUPPORT EQUIPMENT • TT&C SUBSYSTEMS • NARROWBAND/WIDEBAND COMSEC & TRANSEC COMMUNICATIONS • POWER CONVERTERS • DEEP-SPACE TRANSPONDERS • SDLS TRANSPONDERS • NEAR-EARTH TRANSPONDERS • HIGH-DATA-RATE MODEMS • BASEBAND PROCESSORS • SPACEBORNE RADARS • LOW NOISE SYNTHESIZERS • IRIDIUM SYSTEM (SM,TM)

For More Information Circle No. 397

an edge-enhancement mode. This preprocessing increases the orthogonality (with respect to the inner product) between the input image and each of the remembered images, thereby increasing the ability of the memory to discriminate among different images.

The light from the input image is passed through a polarizing beam splitter, a lens, a binary diffraction grating, and another lens, to focus an array of *M* replicas of the input image on one face of a liquid-crystal-television spatial light modulator that is displaying the *M* remembered images. The position of each replica of the input image coincides with that of one of the remembered images. Light from the array of pairs of overlapping input and remembered images is focused by a corresponding array of lenslets onto a corresponding array of photodetectors. The intensity of light falling on each photodetector is proportional to the inner product between the input image and the corresponding remembered image.

The outputs of the photodetectors are processed through operational amplifiers that respond nonlinearly to the inner-product levels (in effect, executing analog threshold functions). The outputs of the amplifiers drive point sources of white light, and an array of lenslets concentrates the light from each source onto the spot occupied by one of *M* remembered images displayed on another liquid-crystal-television spatial light modulator. The light that passes through this array is reflected by a pivoted array of mirrors through a lens, which focuses the output image onto a charge-coupled-device television camera.



This **Optoelectronic Associative Memory** displays whichever (if any) of *M* (in this case, *M* = 4) remembered images resembles an input image most closely.

The output image consists of a superposition of remembered images, the brightest of which are those that represent the greatest inner products (the greatest resemblance to the input image). The television camera feeds the output image to a control computer, which performs a threshold computation, then feeds the images through a cathode-ray tube back to the input liquid-crystal light valve. This completes the associative-recall loop. The loop operates iteratively until one (if any) of the remembered images is the sole output image.

This work was done by Tien-Hsin Chao of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 89 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-18278.

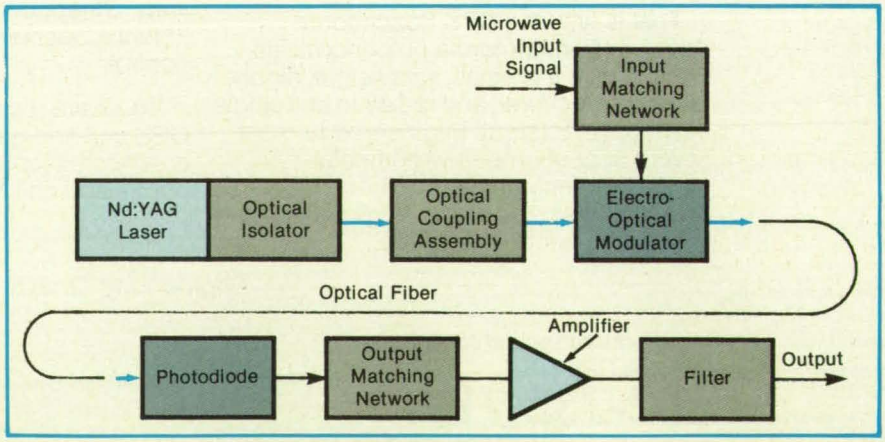
High-Dynamic-Range Fiber-Optic Link for Microwave Signals

Ultrastable systems would provide deep-space antenna up-and-down links.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure illustrates an ultrastable fiber-optic communications system that is being developed to transmit microwave signals (analog, not digital) between antenna sites of the Deep Space Network (DSN) and a central processing station located several kilometers away. When fully developed, these fiber-optic systems would permit relocation of critical receiver and exciter components from the front-end areas of DSN antennas to a central location, thus permitting radio-frequency (RF) antenna arraying, and improving DSN flexibility, maintainability, and system performance. Systems of this type would also be useful in commercial analog and digital communications.

The dynamic range of the cryogenic low-noise amplifiers used to amplify signals received from deep space imposes the requirement that the fiber-optic system dynamic range exceed 140 dB•Hz with less than 5 percent total harmonic distortion at frequencies up to 9 GHz, over several kilometer distances. Heretofore, the dynamic range of commercial fiber-optic communication systems, based on injection-current-modulated semiconductor lasers, has been limited to about 125 dB•Hz. The dynamic range of these prior systems was kept down by several factors: the relatively low



The **Developmental Fiber-Optic Communication System** is expected to be capable of a dynamic-range•frequency of 150 dB•Hz. This new high in performance will be achieved by taking advantage of recent advances in solid-state lasers and electro-optical modulators.

laser power; the nonlinearity of the laser-diode modulation characteristic, which limited modulation depth; the pronounced intensity noise of the semiconductor laser at microwave frequencies; and the excessive optical spectral width and chirp inherent in directly modulated semiconductor lasers, which coupled with fiber dispersion to limit transmission distance.

In the developmental system, the dynamic range is increased by use of a high-power, low-noise laser and a modulator external to the laser. The system takes advantage of recently developed (1) miniature, ultra-low-noise, narrow-spectral-line neodymium:yttrium-aluminum-garnet (Nd:YAG) lasers emitting at 1318.5 nm, pumped by semiconductor diode lasers, and (2) low-insertion-loss lithium niobate ($LiNbO_3$) electro-optical intensity modulators capable of operation up to 18 GHz. An optical isolator is used to prevent reflected light from entering the laser and potentially destabilizing its output, and low-reflection optical interfaces are employed throughout to reduce interferometrically generated noise. The Nd:YAG laser is shot-noise limited above 200 kHz; optoelectronic feedback would be used to reduce its excess intensity noise to adequate levels below 200 kHz.

For the DSN downlink application, the carrier light beam is coupled into the electro-optical modulator, in which the electrical microwave signal from the low-noise amplifier (LNA) is impressed on the optical carrier as an intensity modulation. The modulated optical beam is transmitted out of the antenna over a single-mode optical fiber that has a low thermal coefficient of delay to an optical receiver in the central processing center, which may be located several kilometers away. In the optical receiver, a photodiode converts the optical intensity modulation back into the electrical microwave signal, which is then amplified, filtered, and sent to the first down-convertor stage. Then, only the LNA and the electro-optical modulator would need to be located in the antenna cone area; the Nd:YAG laser source may be located in the central processing center, and the unmodulated optical carrier sent up to the $LiNbO_3$ modulator in the antenna over a separate fiber. All other down-convertor and processing equipment could be conveniently located on the ground in the central processing center. A similar fiber-optic system could also be used to send the microwave output of the uplink exciter to the high-power transmitter in the antenna.

Several advanced commercial diode-laser-pumped Nd:YAG lasers and advanced commercial $LiNbO_3$ electro-optical modulators have been tested in laboratory versions of the system. Calculations of dynamic range and preliminary experiments performed thus far are in excellent agreement and indicate that adequate dynamic range is possible with this type of system for the DSN antenna-remoting application. Further refinements and experiments will be performed to demonstrate this capability in the DSN.

This work was done by Ronald T. Logan, Jr., and George F. Lutes of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 113 on the TSP Request Card.* NPO-18172

Acousto-Optical/Electronic Processor for SAR

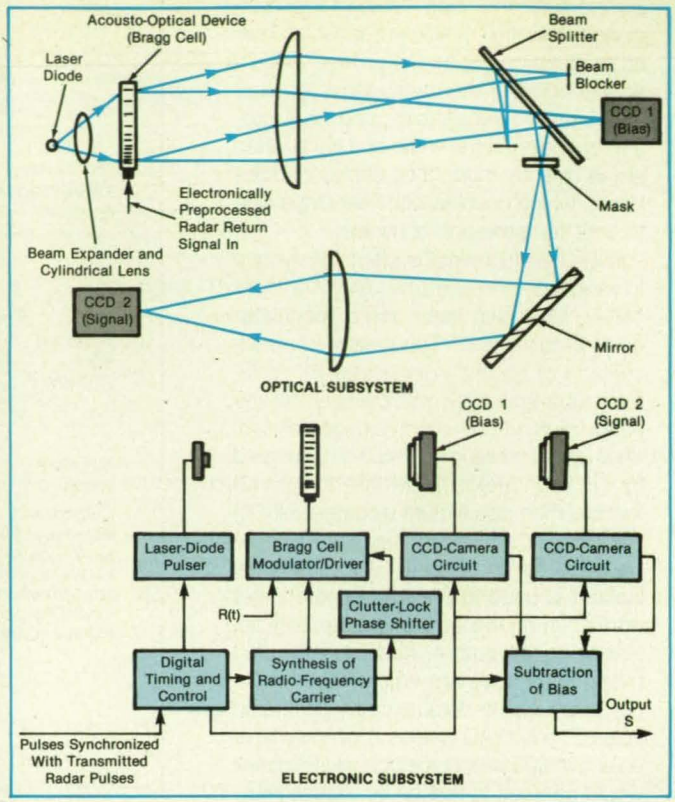
A lightweight, compact, low-power apparatus would process SAR returns in real time.

NASA's Jet Propulsion Laboratory, Pasadena, California

A developmental acousto-optical apparatus operates in conjunction with analog and digital electronic circuits to process frequency-modulated synthetic-aperture-radar (SAR) return signals in real time. The fully developed acousto-optical SAR processor is expected to be a lightweight, compact, low-power apparatus that will provide real-time SAR imagery aboard the moving aircraft or spacecraft SAR platform. The acousto-optical SAR processor has the potential to replace the present all-electronic SAR processors that are now so large and heavy and consume so much power that they are restricted to use on the ground in the postprocessing of SAR data recorded in flight.

The acousto-optical SAR processor uses the range delay to resolve the range coordinate of a target. The history of the phase of the train of radar pulses as the radar platform flies past the target is used to obtain the azimuth (cross-range) coordinate by processing coherently over several returns. The range-compression signal processing involves integration in space, while the azimuth-compression signal processing involves integration in time.

The figure illustrates the optical and electronic subsystems that perform the space and time integrations. The radar return signal is heterodyned to the middle frequency of an acousto-optical device and added electronically to a reference sinusoid to capture the history of the phase of the return signal interferometrically for



The **Acousto-Optical SAR Processor** includes optical and electronic subsystems that, together, resolve the range and azimuth coordinates of radar targets by a combination of spatial and temporal integrations.

compression in azimuth. The resulting signal is applied to the acousto-optical device via a piezoelectric transducer. The acousto-optical device thus becomes a Bragg cell that encodes the evolving SAR return.

Meanwhile pulses of light a few tens of nanoseconds long are generated by a laser diode in synchronism with the transmitted pulses and are used to sample and process the return signal. Lenses shape the laser light into a plane wave incident upon the acousto-optical device. The integration in space is effected at the moment of sampling (the moment when the laser pulse strikes the Bragg cell) by the focusing action of the chirped Bragg grating. The position of the chirped grating within the Bragg cell depends upon the range delay of the corresponding target, and light is brought to focus on two charge-coupled-device (CCD) imaging arrays at positions that depend on the range.

The sinusoidal-reference-signal component of the Bragg grating interacts with the laser illumination to generate a plane wave of light that interferes with the light focused by the chirped range grating. This produces interference fringes that encode the phase information in the range-compressed optical signal. These fringes are correlated with a mask that has a predetermined spatial distribution of density and that is placed in front of, or on, one of the CCD arrays. This CCD array is operated in a delay-and-integrate mode to obtain the desired correlation and integration in time for the azimuth compression. The output image is continuously taken from the bottom picture elements of the CCD array.

Two CCDs are used to alleviate a large undesired bias of the image that occurs at the output as a result of optical processing. CCD1 is used to compute this bias, which is then subtracted from the image of CCD2 to obtain a better image.

This work was done by T. J. Bicknell and W. H. Farr of Caltech for **NASA"s Jet Propulsion Laboratory**. *For further information, Circle 124 on the TSP Request Card. NPO-17468*

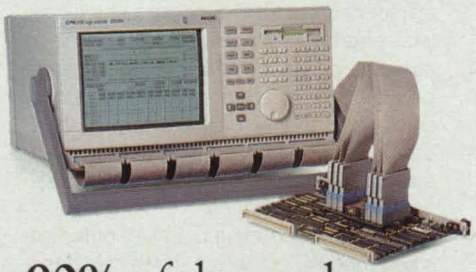
FLUKE AND PHILIPS – THE GLOBAL ALLIANCE IN TEST & MEASUREMENT

FLUKE®

PHILIPS

PHILIPS

Test results:



90% of those who try a Philips Logic Analyzer from Fluke buy one.

100% get a free DMM*.

Our logic analyzers sell themselves. All we have to do is get one in your hands. To make sure you do, we're giving you a Fluke DMM*, whether you buy our analyzer or the competition's. (See attached card for complete details).

Only the Philips PM 3580 family of logic analyzers give you *true* dual state and timing on up to 96 channels - simultaneously. All accessible with one probe and one keystroke. Which means no more dual probing or reconfiguration between state and timing. Or no probes at all if you use our boundary-scan test option!

*The top-of-the-line Fluke 12 in our newest DMM family. It combines a smart set of troubleshooting features in a new design that's exceptionally fast and simple to operate — with one hand. It's yours after our 30 minute demo, no matter whose logic analyzer you purchase.

All our analyzers feature 50 MHz state and up to 200 MHz timing speeds. As well as integrated state and timing triggering for fast debug of complex hardware and software problems. Plus broad µp support like Intel®'s i486; i386; 80286; 80186/88 families. The MCS-96, 8051, and i960 families. And the Motorola 68040 to 6800, 68HC11, 68332/1, 68302, 68340, 56001, AMD®'s AM 29030, and TI's 320Cxx family.

The PM 3580 family of logic analyzers is priced from $4495 to $11,450 - about half the cost of comparable analyzers. What's more you can have them up and running in only 30 minutes.

Find out why the PM 3580 family of logic analyzers were the only ones cited for excellence and innovation by *Electronic Design, EDN, Embedded Systems, Electronic Products*, and *R&D* magazines. Take the Fluke Challenge. The odds are 100% you'll be totally impressed.

For literature, our video or a demonstration, call **1-800-44-FLUKE**.

John Fluke Mfg. Co., Inc., P.O. Box 9090, M/S 250C,
Everett, WA 98206-9090. U.S. (206) 356-5400.
Canada (416) 890-7600. Other countries: (206) 356-5500.

FAST ANSWERS

FLUKE®

For More Information Circle No. 580

Electronic Subsystems for Laser Communication System

The fully developed system is expected to operate at 650 Mb/s.

Goddard Space Flight Center, Greenbelt, Maryland

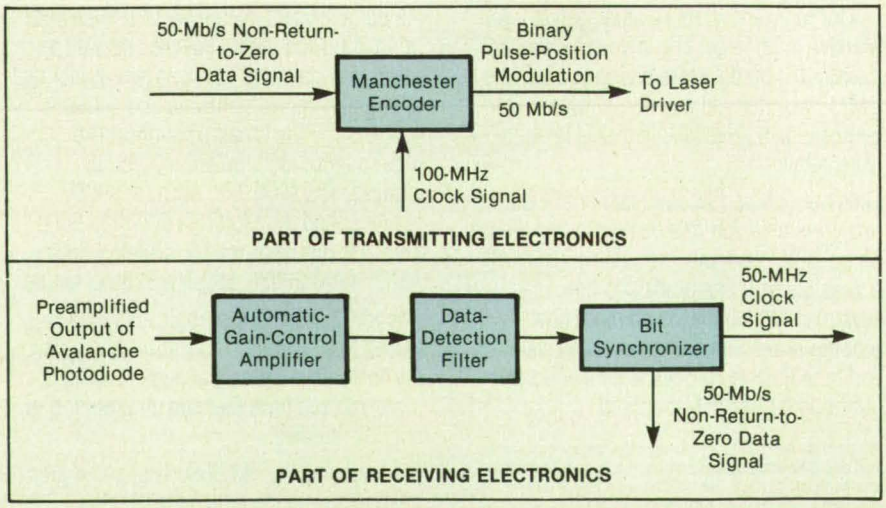
Electronic subsystems of a free-space laser communication system (see figure) have been built and tested. The system is intended to carry digital signals at a rate of 650 Mb/s over long distances when fully developed. Although the specific system is intended primarily for communications with and between spacecraft, the basic concept of the system is applicable to general optical communications that involve the transfer of great quantities of data. One likely application might be the transmission and reception of video images of high definition.

Manchester coding or binary pulse-position modulation, which inherently has a duty cycle of 50 percent, was chosen because of the limitation on the peak powers (as distinguished from the average powers) of laser-driving circuits. To achieve transmission and reception at the required high data rates, high-speed gallium arsenide components and emitter-coupled logic circuits are used. Because the input data signal in the original spacecraft application will be in non-return-to-zero format, it is necessary to convert this signal into binary pulse-position modulation before transmission. The conversion is accomplished in a Manchester encoder, in which each successive non-return-to-zero datum and its complement are loaded into a shift register and shifted alternately at twice the non-return-to-zero data rate. In the subsystems tested thus far, the data rate has been 50 Mb/s.

Because the power of the received optical signal is expected to vary greatly, the receiver includes an automatic-gain-control (AGC) amplifier, which strives to maintain a constant signal power at its output. The AGC amplifier is a closed-loop feedback subsystem in which a square-law detector converts a portion of the output of the amplifier into a voltage that is compared with a reference dc voltage. The difference is amplified and used to control a voltage-controlled attenuator.

The output of the AGC amplifier is fed to a data-detection filter, which is a two-pole Butterworth filter or a three-pole Bessel low-pass filter with a 3-dB cutoff frequency of 50 MHz. This filter reduces the noise in the output of the AGC amplifier. The filtered signal is decoded by a bit synchronizer, which includes a phase-locked loop that extracts the clock signal from the data signal. Other circuitry in the bit synchronizer regenerates the binary pulse-position signal and decodes this signal into a non-return-to-zero signal by use of a maximum-likelihood detection scheme. The bit synchronizer also includes circuitry that resolves a possible 180° ambiguity in the phase of the extracted clock signal.

This work was done by Catherine Long, John Maruschak, Robert Patschke, and Michael Powers of **Goddard Space Flight Center**. *For further information, Circle 115 on the TSP Request Card.*
GSC-13417



Prototypes of these **Subsystems of a Laser Communication System** have been built and tested. Gallium arsenide components and emitter-coupled logic circuits are used to attain high data rates.

Portable Power and Digital-Communication Units

Units would be placed near equipment requiring service.

NASA's Jet Propulsion Laboratory, Pasadena, California

A conceptual network of electronic-equipment modules would provide electrical power and digital radio communications for scientific instruments at multiple sites that are not served by power or communication cables. The system would include a central communication unit and portable units powered by solar photovoltaic arrays. The system was designed for the quick and easy accommodation of both planned and unplanned additions to a collection of scientific instruments aboard the proposed Space Station *Freedom*. A version of the network might also be useful on Earth; for example, to serve equipment that must be set up quickly at remote sites or in buildings that cannot be modified to provide the necessary cable connections. The network could also be deployed to support a system of widely dispersed surface-observation sites for lunar and planetary exploration.

Each portable unit, called a "relocatable utility and communications stand-alone kit" (RUCSAK), would be mounted at its designated instrumentation site, and its solar photovoltaic panels would be deployed from compact storage. Figure 1 illustrates three panel-unfolding options for different space available and peak power required. The solar-power subsystem would supply

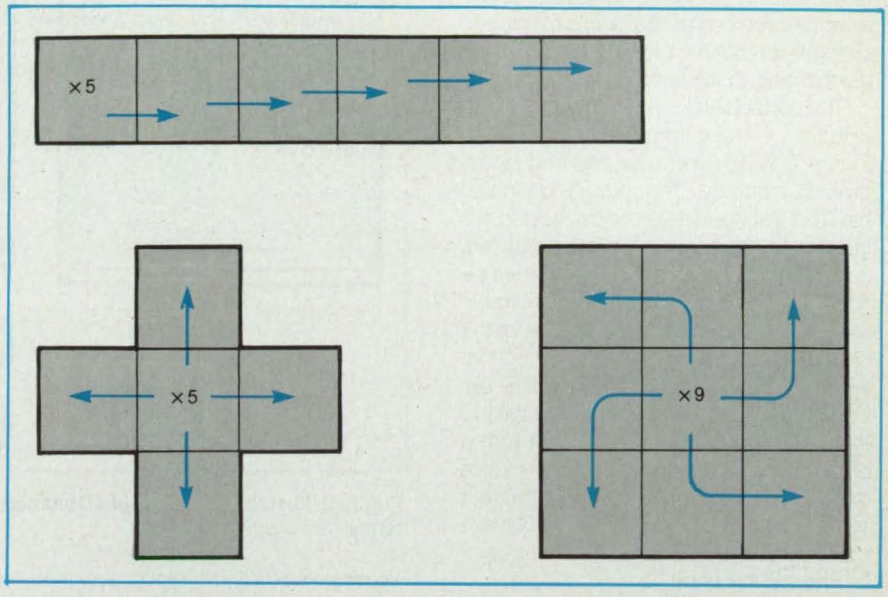


Figure 1. **Solar Panels Would Be Deployed** from compact storage. These alternative deployment schemes are being considered for use in the portable units.

a peak power of about 700 W at 28 Vdc. This would satisfy both continuous demand of 300 W and a peak demand of about 400 W to charge Ni/Cd or Ni/H_2 storage batteries, which would provide power during low insolation. The power subsystem would be designed to operate under a worst-case orbital cycle of charging in sunlight for 50 minutes alternating with discharging in darkness for 41 minutes.

The portable units would communicate with the central communication unit (see Figure 2) in demand-assigned frequency-division multiplex. The radio frequencies have not yet been determined; L-band frequencies were considered in the preliminary analysis. Each portable unit would be equipped with a receiver, a 10-mW transmitter, and an omnidirectional antenna; the communication range would be 300 m with a performance margin of 17.6 dB. Each portable unit would transmit data to the central unit at a rate ≤ 2 Mb/s with a bit-error rate $\leq 10^{-6}$ and would receive data or commands from the central unit at a rate of 0.3 Mb/s. Conceivably, a more powerful unit could communicate directly with the ground.

According to a rough conceptual design, each portable unit would have a mass <80 kg (with Ni/Cd batteries) or <55 kg (with Ni/H_2 batteries). Its volume would be <0.75 m^3. Units designed for less-demanding terrestrial applications would cost considerably less than would space-qualified hardware.

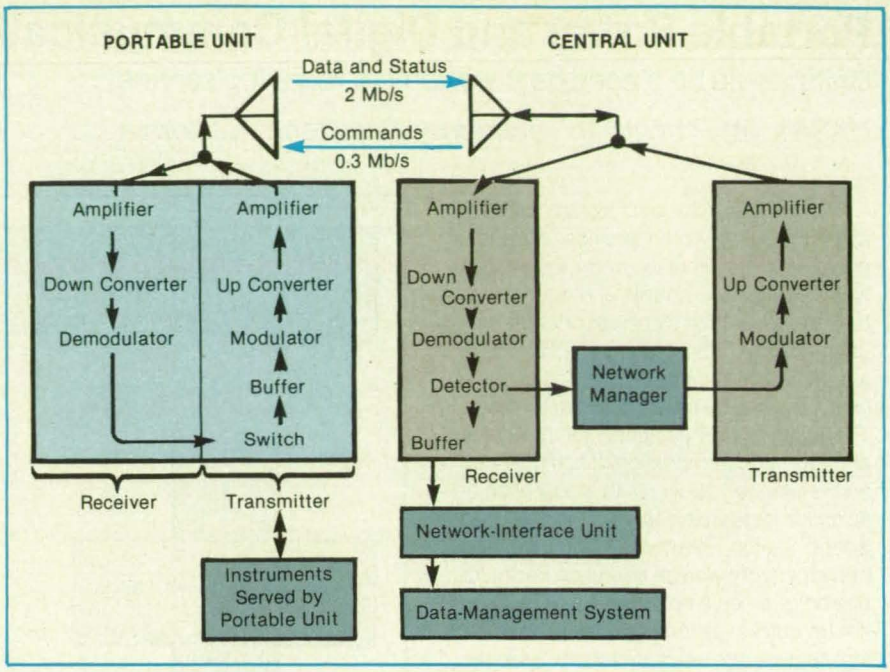


Figure 2. **Portable Units Would Communicate With a Central Unit** over low-power short-range microwave links.

This work was done by Richard R. Levin, Paul K. Henry, and Leigh S. Rosenberg of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 94 on the TSP Request Card.*
NPO-18247

Period Modulation for Telemetry

The demodulator is a simple state estimator, and no discriminator or phase-locked loop is needed.

NASA's Jet Propulsion Laboratory, Pasadena, California

In an innovative telemetry scheme, the time between successive pulses of light transmitted along an optical fiber represents the measured quantity. The scheme is also applicable to radio or wire transmission. The time between pulses can be proportional to temperature, pressure, voltage, or any other suitable continuous variable that is to be monitored remotely.

This scheme, called "period modulation" is related to pulse-position and frequency modulations but is simpler in some respects; for example, unlike in frequency modulation, there is no need for a discriminator or a phase-locked loop in the receiver. The prototype period modulator (see Figure 1) is a variable relaxation oscillator. The output of a ramp generator and a control input that represents the measured quantity are fed to the two input terminals of a comparator. When the ramp voltage reaches the control-input voltage, the comparator puts out a signal that triggers a pulse generator, and the pulse resets the ramp to zero. The cycle then repeats.

If the control-input voltage is increased or decreased, the ramp voltage takes a longer or shorter time, respectively, to reach the control-input voltage, and so the interval between pulses is correspondingly increased or decreased. (If the ramp rate were made variable in response to the control input and if the nonramp input to the comparator were held at a fixed voltage, this subsystem would become a frequency modulator.)

The demodulator (see Figure 2) is a relatively simple "state-estimator" circuit that approximately reproduces what happens in the modulator. In the demodulator as in the modulator, each pulse denotes the end of one ramp cycle and the beginning of the next one. The received pulses start, stop, and reset a ramp generator in the demodulator just as they do in the modulator. The output of the ramp generator in the demodulator is fed to a sample-and-hold circuit. The timing logic circuitry in the demodulator causes the sample-and-hold circuit to retain the ramp voltage that it sampled immediately prior to the arrival of each pulse. This voltage corresponds to the modulating voltage and constitutes the demodulated output.

This work was done by Harold Kirkham of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 121 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be ad-

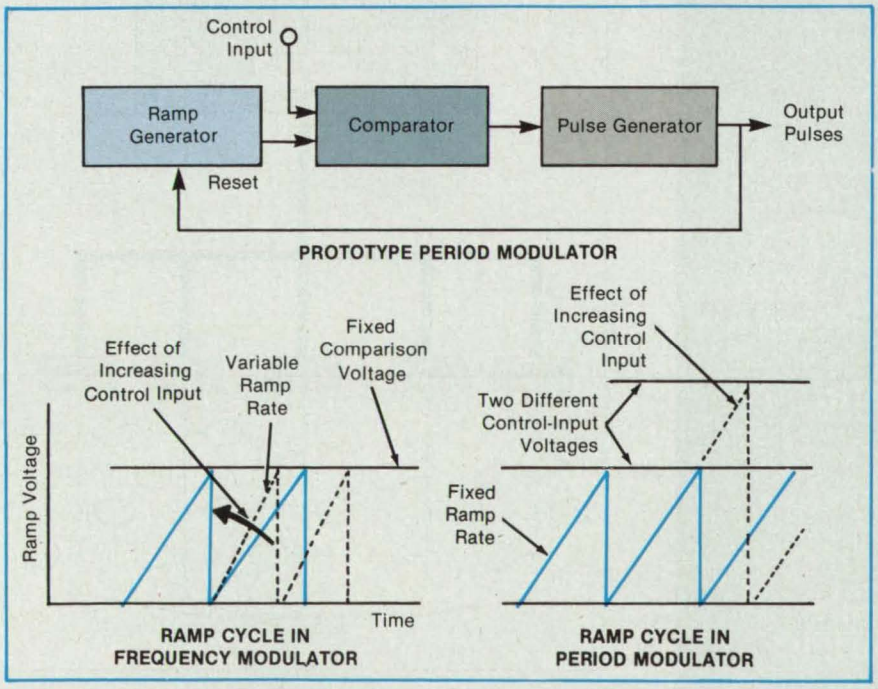


Figure 1. In the **Period Modulator**, the time between pulses is varied by varying the control-input voltage, which serves as the critical voltage of a relaxation oscillator. For comparison, the inputs to the comparator of both this period modulator and a similar frequency modulator are shown.

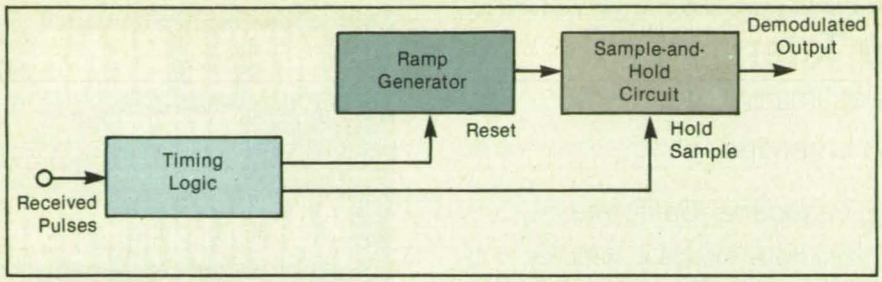


Figure 2. The **Period Demodulator** includes a ramp generator like the one in the modulator. The voltage sampled at the end of each ramp is the demodulated output.

dressed to
Edward Ansell
Director of Patents and Licensing
Mail Stop 305-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125
Refer to NPO-18002, volume and number of this NASA Tech Briefs *issue, and the page number.*

Spreadsheet Analysis of Queuing in a Computer Network

Effects of variations in traffic, capacities of channels, and message protocols can be assessed.

Ames Research Center, Moffett Field, California

A method of analyzing the responses of a network that carries messages among computers is based on the implementation of a set of simple queuing-theory mathematical models via a spreadsheet computer program. The purpose of such an analysis is to determine the effects of variations in traffic, of the capacities of channels, and of message protocols, specifically to answer such questions as the following:

- What is the response time of the network over every path?
- What are the effects of changes in the traffic pattern on the response and capacity of the network?
- What is the effect of changing one or more of the facilities?
- Given a specified response (or, more generally, turnaround) time, what facilities are required to achieve it?

The method and the queuing-theory models in it are based on a number of simplifying assumptions regarding the rates of arrival of messages at the nodes of the network, the rates of sensing and routing of messages, the sufficiency and reliability of equipment at every node, the loopless flow of messages in the network, and the disappearance of a message from the network once it arrives at its destination (this quality is called the "openness" of the network). The method involves no assumptions about the distribution of service times. Such assumptions are unnecessary; queuing theory is sufficiently developed to handle such distributions.

Because the network is assumed to be open and loopless, the end-to-end delay for a packet is simply computed as the sum of the individual delays in each subnetwork and in the various gateway sys-

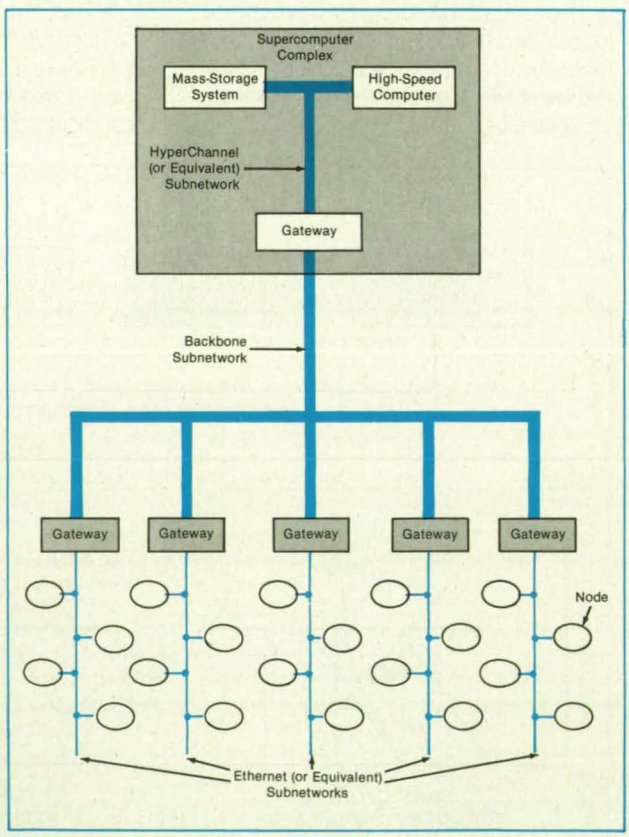
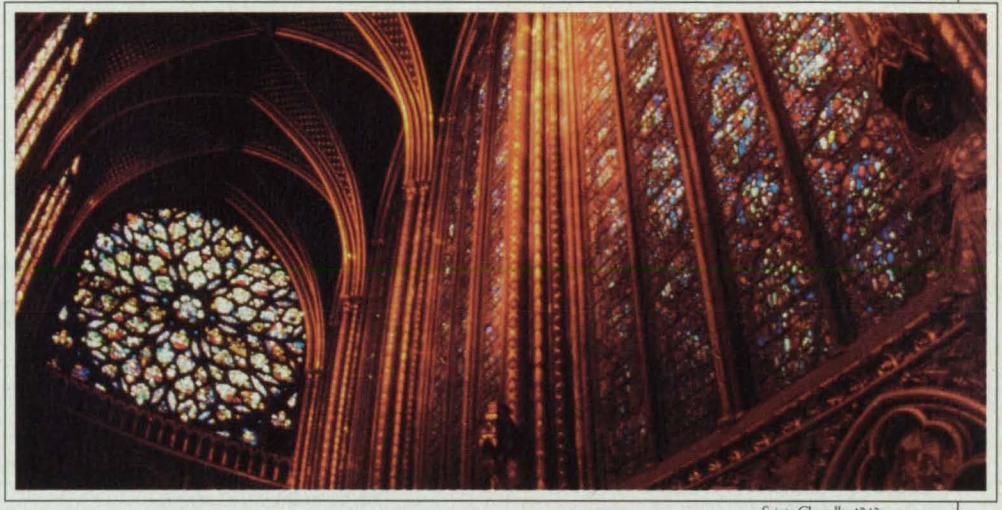


Figure 1. The **Traffic on This Conceptual Network** was analyzed by the queuing-theory/spreadsheet method described in the text to demonstrate the method.

Every 800 years or so, someone does something with Windows that becomes the standard by which all others are judged.



Sainte Chapelle, 1243.

At Data Translation, we think that this is our most inspired data acquisition and image processing announcement ever.

DT-Open Layers
FOR MICROSOFT® WINDOWS™

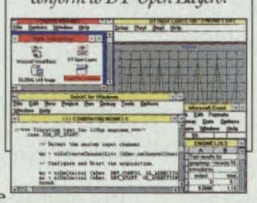
That's because we're introducing DT-Open Layers,™ a modular software architecture for Microsoft® Windows.™ In basic terms, DT-Open Layers is a set of specifications that establishes standards for developing software to run on a PC, in a Microsoft Windows environment.

And in much broader terms, it is something that will change the lives of everyone involved in data acquisition and image processing. From end users to software developers to OEMs.

Data Acquisition And Image Processing Investment Protection.

DT-Open Layers protects your investment by allowing you to add new hardware or software functions, without changing the code in your existing software. It also makes it possible to integrate hardware and software from multiple vendors.

From now on, every hardware or software product that Data Translation develops will conform to these new standards. For example, you can call today and get GLOBAL LAB, our powerful, easy-to-use series of applications and libraries. What's more, we're offering DT-Open Layers free to any software developer, OEM, or end user who wants it. And a number of companies are already developing products using the DT-Open Layers specifications.



Our GLOBAL LAB products were written for Windows, and conform to DT-Open Layers.

So if your job involves data acquisition or image processing, you owe it to yourself to find out about DT-Open Layers now. Call us today for a free brochure and our product handbook, at **508-481-3700.**

Or if you're a developer, an OEM, or just curious, call and we'll send you the specs, free. But call now. Because this is truly a window of opportunity you won't want to miss.

Add our proven hardware to DT-Open Layers, and you've got the best of both worlds.

DATA TRANSLATION®

World Headquarters: 100 Locke Drive, Marlborough, MA 01752
508-481-3700, Fax: 508-481-8620

For More Information Circle No. 349

tems between the subnetworks. In other words, the mathematical model of the network is decomposed completely, making it possible to model pieces simply in relative isolation. The only effect of one piece of the network upon another is the induced traffic load.

The prediction of the behavior of a network requires knowledge of the traffic load. The distribution of the sizes of message packets, the rates of transmission of packets, and the service time required to send a packet are sufficient to model the average behavior of the network under the given traffic load. Once the isolated behavior of the individual links in the network and the flow of traffic through the network are known, the transmission delay between two nodes for a file many packets long can be calculated.

A typical network (see Figure 1) generates a large number and variety of messages, the flows of which are approximated by the various queuing-theory models. The spreadsheet program calls upon each model as needed to account for each of the many components of messages that flow within and between the subnetworks and thereby determines the overall rates of flow of data under various assumed conditions (see Figure 2).

Rate of Arrival of Packets (Number per Second)	Utilization of Channel	Response Time, ms	Average Number of Packets in Queue	Effective Rate of Transfer, Mb/s	Actual Rate of Transfer, Mb/s
400	3.12%	0.09	1.18	72.74	2.27
411	3.20%	0.09	1.18		2.33
800	6.23%	0.09	1.20		4.53
1,200	9.35%	0.10	1.24		6.80
1,600	12.47%	0.10	1.27		9.07
2,000	15.58%	0.10	1.31		11.33
2,055	16.01%	0.10	1.31		11.65
2,466	19.21%	0.11	1.35		13.97

Figure 2. The **Response of the Backbone** subnetwork of the network of Figure 1 was computed for various rates of arrival of message packets, using a number of assumptions concerning the statistics of the traffic mix and the capacity and propagation delay of the subnetwork cable.

This work was done by David C. Galant of **Ames Research Center**. *Further information may be found in NASA TM-101056 [N89-20770], "Queuing Theory Models for Computer Networks."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-12726

Computer-Based Laboratory for Engine-System Monitors

Hardware and software would be evaluated initially without potentially hazardous measurements on actual engines.

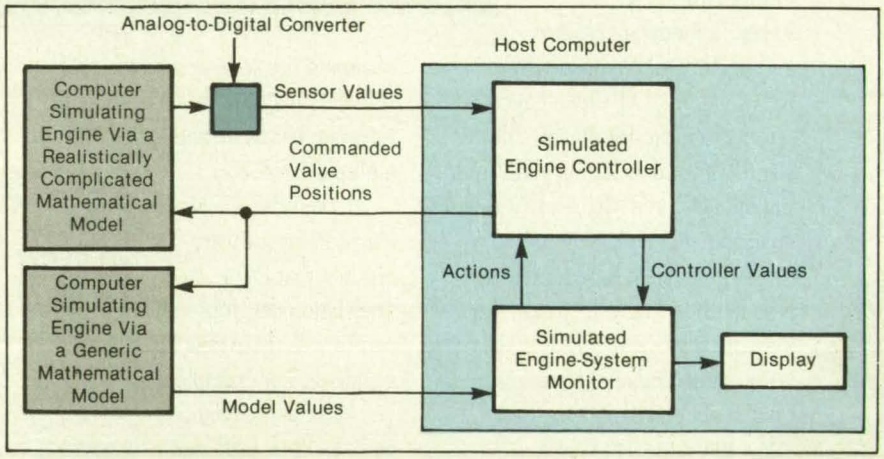
Marshall Space Flight Center, Alabama

A proposed laboratory would be used to evaluate candidate artificially intelligent enine-system monitors. The laboratory would test various software packages and computer configurations at low risk and relatively low cost.

The laboratory would contain three computers (see figure): a host microcomputer that would simulate the engine-system monitor and the engine controller, a computer that would simulate the engine by use of a realistically complicated mathematical model, and a computer that would simulate the engine by use of a generic model. It would not be necessary to calibrate the generic model to a specific engine because this model would treat only relative changes [for example, a change of 1 percent in the level of power might produce a change of 10 °R (about 5.6 °C) in turbine-discharge temperature].

The purpose of an engine-system monitor is to enhance the engine controller by detecting undesirable trends and counteracting them. The engine-system monitor would do this by comparing the performance of the more-realistic mathematical model of the engine with that of the generic model of the engine when both models receive the same commands from the engine controller.

Thus, for example if the engine-system monitor were to find that the relative change in a given parameter of operation of the more-realistic model exceeded the relative change of the corresponding parameter of the generic model during steady-state or power-transient operation, the monitor would set the electronic equivalent of a flag. Its expert system would then examine relevant sensor signals and determine whether a known scenario is occurring. Once the expert system identified an anomaly, the engine-system monitor would order an appropriate course of action through the engine controller.



The **Host Computer Would Communicate** through analog-to-digital converters with a computer implementing a realistically complicated mathematical model of an engine, and through digital lines with a computer implementing a generic mathematical model of the engine. The simulated engine controller would keep the "real" and generic engines in synchronism by sending them the same valve-control signals.

For example, if the engine-system monitor were to find any faulty sensors, it would disqualify signals from them but would not necessarily turn the engine off. It could move the engine to a safer operating point, command a shutdown, or decide whether continued operation or a shutdown is appropriate according to the severity of the fault and the time of occurrence of the fault in the sequence of operations.

The laboratory would use expert-system-development software for research

on, and development of, the engine-system monitor. The laboratory would be used to evaluate the performances of specific engine-system monitors — for example, to determine whether they are fast enough to perform their assigned tasks in real time. It could test such alternative monitor concepts as those based on neural networks. It could compare microcomputers and communication media. Once a monitor had been thoroughly proved in the laboratory, it could then be tried on a real engine.

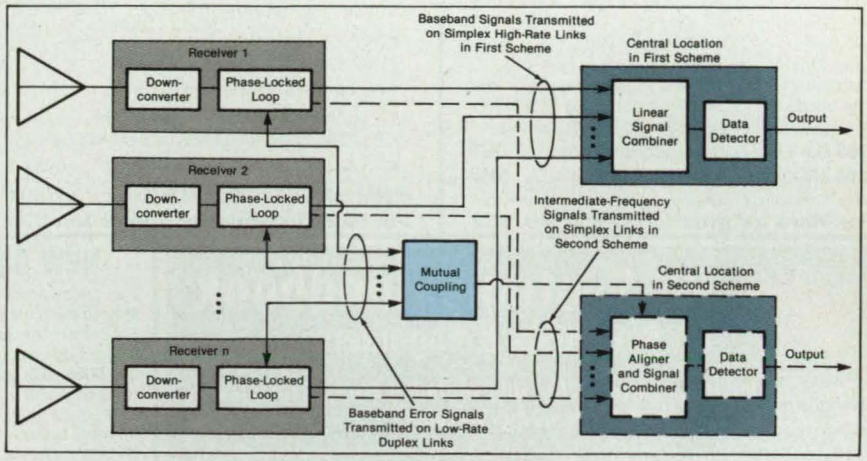
This work was done by Robert B. Aguilar and Raul C. Garcia of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 21 on the TSP Request Card.*
MFS-29793

Receiver-Coupling Schemes Based on Optimal-Estimation Theory

Optimal cross-coupling of phase-locked loops would improve performance.

NASA's Jet Propulsion Laboratory, Pasadena, California

Two proposed schemes for the reception of weak radio signals conveying digital data via phase modulation provide for (1) the mutual coupling of multiple receivers possibly located at great distances from each other and (2) the coherent combination of the outputs of the receivers at baseband or an intermediate frequency (see figure). The mutual coupling would be weighted baseband cross-coupling among the phase-locked loops of the receivers; it would be implemented digitally, governed by algorithms that compute optimal cross-coupling weights. Although the schemes were devised for spacecraft communication systems, they should be applicable to terrestrial systems: multiple-receiver "diversity-reception" systems have been used for years in terrestrial radio communications.



Phase-Locked Loops Would Be Coupled and outputs of receivers would be combined according to two schemes. In both schemes, optimal mutual-coupling weights would be computed according to Kalman-filter theory. The two schemes would differ in the manner of transmission and combination of the outputs of the receivers.

In the first scheme, the phase-locked loops of the receivers would be coupled in such a manner that each loop is aided optimally by the other loops in acquiring and tracking the phase of its received signal. The optimal coupling weights would be feedforward and feedback Kalman-filter gain matrices. The in-phase and quadrature baseband outputs of the receivers thus coupled would be transmitted to a central location (which could be one of the receivers) at an information rate consistent with the transmission rate of the data that one expects to detect. At the central location, the baseband signals would be combined linearly, then processed in the usual manner to detect the data.

Theoretical analysis and computer simulations show that the detection performance of the first scheme would be nearly optimal if the phase processes of the radio signals received at the various locations were highly correlated. However, that component of the improvement in performance that would be attributable to cross-coupling would diminish with a decrease in correlation, reaching zero when the correlation coefficient reached zero. In the low-correlation case, most of the improvement in performance would be expected to result from combining the baseband signals.

This leads to the second scheme, which retains the mutual coupling but differs in the manner of combining the outputs of the receivers. In this scheme, the signals would be transmitted to the central location at an intermediate frequency and combined nonlinearly, making use of the estimation-error information provided by the mutual-coupling stage to align the phases of the various signals with the phase of a composite signal.

For the purpose of removing the data modulation from the loop error signals, a decision-directed approach is used wherein a differential detection scheme, involving detection of phase transitions in the signal at the combiner output, is made an integral part of the coupled system. Such a scheme would yield a better acquisition performance than the usual matched-filter detection scheme, as the former is tolerent of considerable frequency estimation errors, unlike the latter, during the acquisition phase. Calculations show that this scheme would be optimal when the ratio between the symbol energy and the spectral density of noise at the output of the combiner (E_s/N_o) was relatively high. The method can be easily extended to situations of low E_s/N_o at the cost of some extra complexity by increasing the detection interval to multiple symbol periods.

This work was done by Rajendra Kumar of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 66 on the TSP Request Card.*
NPO-18227

Automatic Detection of Faults in Turbomachinery Bearings

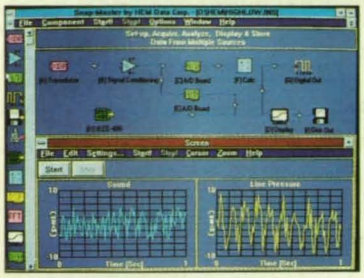
Indications of actual faults and incipient failures would be extracted from vibrations.

Marshall Space Flight Center, Alabama

A proposed system of analog and digital signal-processing equipment, computers, and computer programs would detect faults in, and predict the remaining operating time until failure of, ball bearings in a turbomachine. The system would operate in real time, extracting the diagnostic and prognostic information from vibrations sensed by accelerometers, strain gauges, and/or acoustical sensors and from the speed of the machine as measured by a tachometer.

CyberResearch MAY PRODUCT SHOWCASE

NEW Snap-Master Software: Data Acquisition for Windows



Discover Snap-Master — the only Windows-based data acquisition and analysis software to achieve high-speed, real-time data acquisition with multiple simultaneous A/D boards.

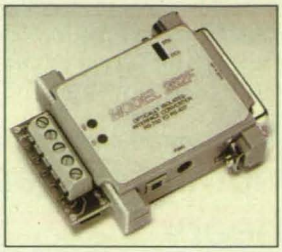
Snap-Master lets you define your own custom instruments using icons and easy-to-understand flow charts. A pre-defined database of sensors is integrated with the data acquisition system.

#HDS 200 Snap-Master Acquisition Module.....**$995**
#HDS 210 Snap-Master Analysis Module **$495**

Use modules as an integrated package or stand-alone

For More Information Circle No. 362

Opto-Isolated RS-422 Converter



Your computer can be protected at the power supply, but suffer a devastating shock from power surges picked up over long data lines. The **COMH 262** converter module from **Telebyte Technology** serves double-duty, providing both high-speed RS-232 to RS-422 conversion *and* optical isolation.

- **Optical isolation exceeds 10,000 Volts**
- Earth ground connection
- Switch selection of DCE or DTE
- LED status indicators on data lines
- Wall transformer powers the unit
- Data Rates to 19K baud over 2 **miles**
- RS-232 Connector: DB-25 (select Male/Female)
- RS-422 Connector: 4 screw terminals + ground

#COMH 262 Isolated RS-232/422 Converter.....**$139**

For More Information Circle No. 370

DAC 812: Eight Precision D/A's

Brand new from **Analogic Corp.**, the **DAC 812** is a low-cost D/A (Analog Output) board designed for use in many different applications. Each of the 8 D/A channels can be independently configured for one of 5 jumper-selectable ranges or for 4-20mA current-loop output. Channels may be sequentially or simultaneously updated, with all channels resetting to 0V (or 4mA) on power up.

24 Digital I/O lines are built into the **DAC 812** which may be used for TTL-level applications.

Software driver libraries in Microsoft C & Turbo C and a calibration utility are provided with the board, along with a user-friendly setup program to make getting started with the **DAC 812** easy.

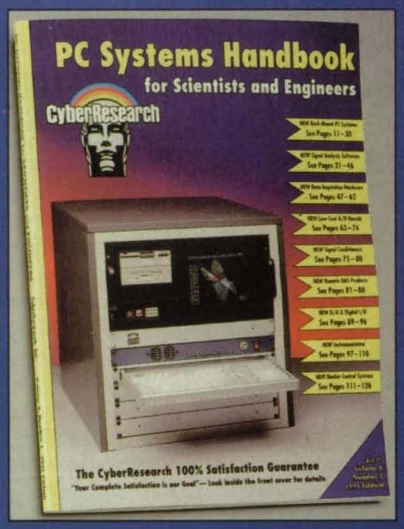
An optional Screw Terminal Panel in a rugged RFI-Shielded hard plastic box is available as an accessory, complete with 2-meter shielded cables.

#DAC 812 8-Channel 12-Bit Analog Output Bd.....**$599**
#DAC STB Rugged. RFI Terminal Box w/Cables **$400**

For More Information Circle No. 371

FREE PC Systems Handbook for Scientists & Engineers

This Combination Tutorial/Catalog Includes Many Examples of PC-based Scientific & Engineering Systems



Have you wanted to enjoy the many benefits of configuring your own PC-based Data Acquisition or Instrumentation system, but didn't know where to begin? The **PC Systems Handbook** will lead you every step of the way, explaining all aspects of systems configuration with easy-to-understand text and clearly documented diagrams. A detailed glossary and two dozen "Tech Notes" help you understand the terminology. Our new **1992 Edition** will be expanded to 196 pages with a hard spine, making it suitable as a permanent addition to your bookshelf. And there is **absolutely no charge** for this invaluable reference book.

Topics Covered Include:

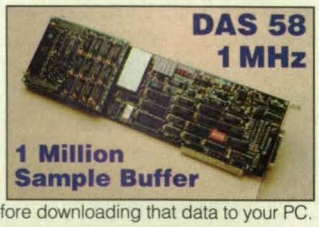
- **Industrial Rack-Mount PC's — AT, 80386, & New 80486 Models**
- **Real-Time Data Acquisition, Analysis, & Process Control Software**
- **PC Plug-in Boards for Analog/Digital, Digital/Analog, & Digital I/O**
- **Connect your PC to Test Instrumentation with IEEE-488, RS-232, RS-422**
- **Stepping and Servo Motor Control with your Personal Computer**

Circle the Information Number below to reserve your own free copy of the 1992 edition of this invaluable guide. Or call the CyberResearch Toll-Free Applications Hotline to receive our latest edition more rapidly.

TOLL-FREE APPLICATIONS HOTLINE
(800) 486-8800

For More Information Circle No. 366

NEW DAS 58 offers 8 Channels @ 1 MHz



The latest product from **Keithley Metrabyte** is the powerful **DAS 58**. An 8-channel redesigned version of the highly-successful DAS 50, the **DAS 58** provides full 12-bit resolution of all samples, and comes with a large on-board memory buffer. This buffer allows you to capture up to 1 million samples (1 full second at the 1 MHz maximum speed of the DAS 58) before downloading that data to your PC.

The optional **SSH 58** provides simultaneous sampling of the 8 input channels to within 35ns *without the need for any additional programming.*

#DAS 58 8-Channel, 1MHz, 12-Bit Data Acquis. Board w/Software **$2350**
#SSH 58 8-Channel Simultaneous Sample & Hold Panel for DAS 58.....**$699**
#K 1800 Cable from DAS 58 to SSH 58.....**$30**
#ASO 58 Advanced Software — Windows 3.0, Pascal, & C Drivers.....**$99**

For More Information Circle No. 369

New GPIB Controllers Support IEEE-488.2 Standard

The new IEEE-488.2 standard has made it easier than ever to program & control GPIB devices. Manufactured by **National Instruments**, these boards allow you to control and gather data from up to 15 devices with IEEE-488 interfaces. Our **AT GPIB** and **Micro-Channel** controllers support data transfers at up to 1 Million samples/second. (No re-writes! Older software fully supported!)

#INST 1000A Standard GPIB Controller with IEEE 488.2 Support.....**$395**
#INST 1004 AT-Bus, 1 MHz Turbo GPIB Controller.....**$495**
#INST 1011 Micro-Channel, 1 MHz Turbo GPIB Controller **$495**
#IEEE 30-2 2-Meter GPIB Cable (Many styles avail. – call for info!) **$59**

For More Information Circle No. 368

Rugged Industrial Rack-Mount PC's

These are the most rugged PC's available **anywhere**. Each unit includes such features as: A heavy steel chassis to eliminate EMI/RFI problems, a 12-slot passive backplane, a single-board CPU which protects system components from shock and vibration, and a protective door to cover the disk drive opening. Additional protective features include a shock-isolated mounting panel for a 3.5" hard drive, an industrial-quality power supply which provides line filtering with surge suppression, and dual fans to pull air through a modacrylic filter.

#IPC 286-16 Industrial Rack-Mount 16 MHz 80286 Computer **$2695**
#IPC 386-25S Industrial Rack-Mount 25 MHz 80386sx Computer **$2995**
#IPC 386-33 Industrial Rack-Mount 33 MHz 80386 Computer **$3695**
#IPC 486-33 Industrial Rack-Mount 33 MHz 80486 Computer **$4495**

For More Information Circle No. 367

Digital Products DataCommander

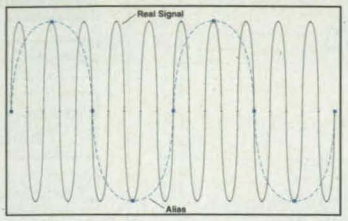
New **DataCommander**™ Serial Port Multiplexers operate independently of your host PC. Achieve high-speed data collection and communications from many sources without taxing your PC's main processor. On-board 250K memory buffer (upgradeable to 4MB) and on-board microprocessor make the DataCommander™ a powerful acquisition tool. **Your PC can be executing other tasks while the unit spools up to 4MB of incoming data.**

Ports on these units use DB 25-pin connectors. **Custom configurations** are available featuring RS-422 (long distance) lines, RJ-11 / RJ-45 connectors, and parallel port options.

#DCOM 600 6-Port RS-232 DataCommander™.....**$995**
#DCOM 1000 10-Port RS-232 DataCommander™ ...**$1495**
#DCOM 1610 16-Port RS-232 DataCommander™ ...**$1995**

For More Information Circle No. 372

Avoid A/D Sampling Disaster



Anti-Aliasing filters are the only protection to prevent unwanted high-frequency waveforms from appearing as low-frequency signals. Give yourself the best protection with **R. C. Electronics'** instrumentation-quality RC-AAF programmable low-pass filters for 12- and 16-bit data acquisition systems. Compatible with any data acquisition or PC-based system.

- 8-pole Cauer elliptical, Bessel, or Butterworth filters.
- Frequency range 1 Hz to 100 KHz.
- Roll-off: > 82 dB/octave
- Stopband attenuation: > 94 dB
- Frequency step resolution: .001 Hz to 10 Hz

#AAF 8 8-Channel Anti-Aliasing Filter **$4995**
#AAF 16 16-Channel Anti-Aliasing Filter **$7950**

For More Information Circle No. 360

Redlake TapeCaster VGA to Video Converter

Redlake's new ***TapeCaster*** converts VGA screen output to video for applications such as computerized animation and creating training tapes. The *TapeCaster* is extremely easy to use: no base addresses, no interrupts, no software — just plug and play.

- True, precise NTSC or PAL video timing.
- Simultaneous VGA and video display.
- Composite Video & Y-C (SuperVHS) output for use with equipment ranging from a home VCR to broadcast-quality professional video.

#NTSC 200 TapeCaster - NTSC Video Output.....**$750**
#PAL 200 TapeCaster - PAL (Europe) Video Out. ..**$750**

#NTSC 100 Spectrum-NTSC Video Digitizer and VGA Overlay Controller with software.....**$1650**

NOTE: **Save $200** – when purchasing *Spectrum- NTSC* & either *TapeCaster* together, deduct $200 from the price.

For More Information Circle No. 375

Directly Interface to Any Type of Transducer

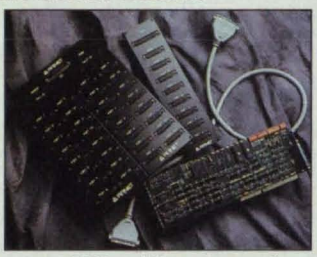
When you need to measure several types of inputs, but your budget won't support the high cost of signal conditioning modules, there is only one solution: The **UPC Direct Sensor Input Cards** from **Validyne Engineering.**

- Directly connects to Thermocouples, Strain Gauges, RTD's, LVDT's, RVDT's, Voltage Sources, and Resistance Devices.
- 16 A/D Inputs w/14-Bit Resolution
- Acquisition at 20,000 samples/sec.
- Perfect for Portable PC DAS Systems
- Complete with *Easy Sense* Software, Software Drivers, and a specially-designed Screw Terminal Panel.

#UPC 601 20 KHz Direct Sensor Input Card w/Software & Term. Panel.**$1795**
#UPC 608 20 KHz Direct Sensor A/D with 2 D/A's & 16 DIO's **$2395**

For More Information Circle No. 373

Arnet Intelligent Serial Boards



Your PC is no longer limited to 2 serial ports! Multi-port serial boards from Arnet let your PC support up to 66 serial ports. All Arnet boards come complete with DOS Driver Software and an external 25-pin "D" connector box.

- Intelligent units offer on-board 80186 micro-processor and dual-ported RAM buffer.
- **Free** driver software lets DOS recognize up to 66 COM: ports.
- **SurgeBlock**™ on all ports protects your PC from killer voltage spikes.
- "Rock-Solid" **Lifetime Warranty**.

#COMH 104 4-Port Intelligent Serial Board **$595**
#COMH 108 8-Port Intelligent Serial Board **$995**
#COMH 116 16-Port Intelligent Serial Board **$1895**

For More Information Circle No. 374

Your PC can Control a Servo Motor System

Complete motion control systems from CyberResearch include all of the components you need to set up an intelligent yet powerful motor system. The system featured here offers high speed and closed-loop control for accurate positioning:

- ***Technology 80*** 2-Axis Intelligent Servo Motor Controller with software.
- ***Torque Systems*** (Qty 2) Servo Motor, 140 oz-in/1300 RPM w/integral encoder
- ***Technology 80*** 2-Axis, 7 Amp analog servo driver.
- ***Electrostatics*** Regulated DC Power Supply
- Terminal Panel and Cabling

#CSVS 872A High Torque, Dual-Motor, Analog Servo Control System **$2995**

For More Information Circle No. 361

CyberResearch

PC Products for Scientists & Engineers

Wide Selection of Products

When you need PC-compatible equipment for science and engineering, there's only one name to think of: **CyberResearch.** We offer the largest selection of hardware and software for data acquisition, instrumentation, communications, motion control, etc. We stock all your best-known suppliers like those featured on these pages and many more.

FREE Application Engineering

At CyberResearch we have no salespeople. Our engineers have one priority: to help you find the best technical solution to your problems. Calling our Applications Hotline is like having your own free consultant. Call and let our experience work for you.

100% Satisfaction Guarantee

You can order from CyberResearch with confidence. If you are not completely satisfied with your purchase, simply call our toll-free hotline within 30 days of receiving the item. A friendly customer service technician will arrange for a full refund, replacement, exchange, or credit. **No Problem. No Hassle.**

It's Easy to Order

We accept Purchase Orders from:

- Government Agencies
- Fortune 500 companies
- Universities & hospitals

If you don't fall into one of these categories, you can place orders prepaid with a credit card or check or COD with a company check.

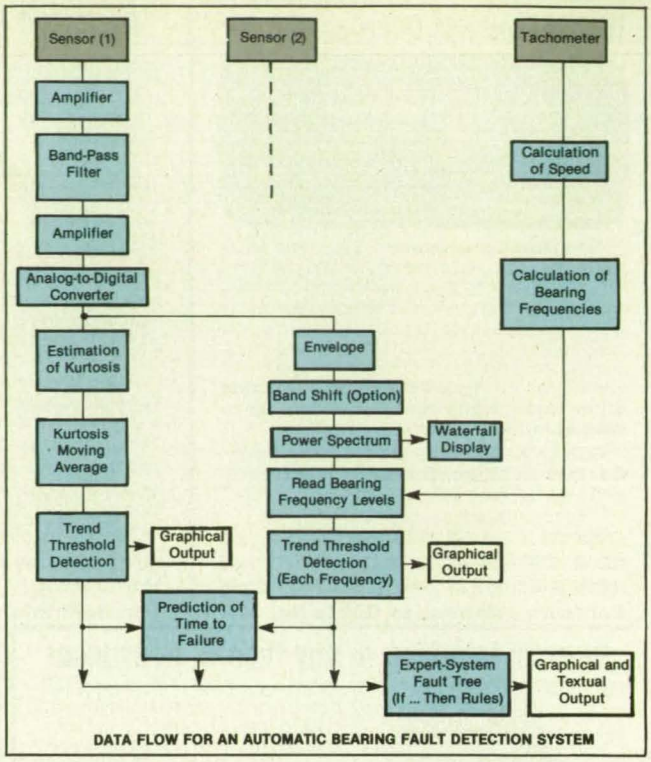
We accept MasterCard and Visa. American Express orders require a 5% surcharge. We pay ground shipping charges on all orders prepaid by check.

Mailing Address:
P. O. Box 9565
New Haven, CT 06535

Worldwide
(203) 483-8815
Fax: (203) 483-9024

TOLL-FREE APPLICATIONS HOTLINE
(800) 486-8800

For More Information Circle No. 366



DATA FLOW FOR AN AUTOMATIC BEARING FAULT DETECTION SYSTEM

The **Flow of Data** in the fault-detection-system would involve computations of (1) kurtosis of the distribution of amplitudes and (2) the power spectrum and its relationship with the bearing frequencies. The final result of all computations would be graphical and textual displays indicative of the condition of the bearing(s).

The vibrations that one seeks to identify are those caused by impacts that occur when pits in balls make contact with races and pits in races make contact with balls. These vibrations have patterns that are unique to bearings and repeat at known rates that are related to ball-rotation, ball-pass, and cage-rotation frequencies. These vibrations have a wide spectrum that extends up to frequencies of hundreds of kilohertz, at which the noise component of the overall spectrum is relatively low.

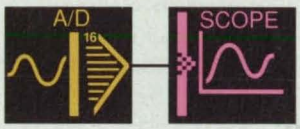
The system (see figure) would accept input from one or two sensors. Each input signal would be amplified, band-pass-filtered, and digitized. The digitized signal would be processed in two channels: one to compute the kurtosis of the distribution of amplitudes, the other to calculate the frequency content of the envelope of the signal. The kurtosis is the fourth statistical moment and is known, on the basis of theoretical and experimental considerations, to be indicative of vibrations caused by impacts on faults. The kurtosis would be calculated as a moving average for each consecutive digitized sample of the signal, using a number of samples specified by the technician. The trend of the kurtosis moving average would be computed several times per second, and changes in the kurtosis value that are deemed to be statistically significant by virtue of exceeding a threshold would be reported.

In the other signal-processing channel, the amplitude envelope of the filtered, digitized signal would first be calculated by squaring the signal. Optionally, the high-frequency sampled data could be shifted to a lower frequency band to simplify processing by enabling the use of a smaller fast Fourier transform. This transform would then be applied to compute the power spectrum.

The output of the tachometer would be processed in parallel with the spectral calculations so that the frequency bins of the power spectrum could be normalized on the basis of the speed of rotation of the machine. The power spectrum would be

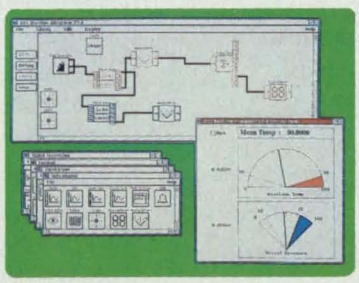
WHICH WOULD YOU RATHER WRITE?

```
/*
 C_EXAMPLE.C
   This program reads 100 values from channel 2 of the AXV11-C then
   displays the data in a graph on the screen.

   This is a simple application using the DECRTI libraries.

   This program can be compiled, linked, and run as follows:
        $CC C_EXAMPLE
        $LINK C_EXAMPLE, SYS$INPUT/OPT
        Sys$libfary:VAXCRTL.EXE/share
        <CTRL-Z>
        $RUN C_EXAMPLE
*/

#include <lioset.h>             /* LIO set parameter definitions */
#include <decrti.h>             /* DECRTI routine definitions */
#include descrip                /* string descriptor definitions */
#include stsdef                 /* STATUS value bit definitions */

main()
{
/* Declare local variables */
      int STATUS        /* STATUS returned by LIO routine calls */
         ,axv_id        /* LIO-assigned device ID */
         ,data_length   /* number of data bytes to read */
         ;

/* Declare the string descriptors for the string constants */
       $DESCRIPTOR (dev_type, "AXA0:");    /* AXV11-C device type */
       $DESCRIPTOR (mode_string, "IXSY");  /* LGP$PLOT mode string value */
       $DESCRIPTOR (xlabel, "Time");       /* LGP$PLOT x-axis label */
       $DESCRIPTOR (ylabel, "Voltage");    /* LGP$PLOT y-axis label */
       $DESCRIPTOR (title, "C_EXAMPLE");   /* LGP$PLOT graph title */

/*
Declare data buffer for raw data in LSP$FORMAT_TRANSLATE_ADC. This
is a word (16-bit) array containing 100 elements.
*/
   short int raw_data[100];
/*
Declare data buffer for voltages in LSP$FORMAT_TRANSLATE_ADC and
LGP$PLOT routines. This is a single-precision, floating-point
array containing 100 elements.
*/
    float voltages[100];

/* Program execution */

/* Set up the AXV11-C */

    printf("C_EXAMPLE, Read data, convert it, plot it\n\n");

/*
Attach the AXV11-C and set up for mapped (polled) I/O. This routine
call returns an LIO-assigned device ID for the device.
*/
        STATUS = LIO$ATTACH (&axv_id, &dev_type, &LIO$K_MAP);
                 if(!(STATUS & STS$M_SUCCESS)) LIB$SIGNAL(STATUS);

/* Set up the AXV11-C to use the synchronous I/O interface. */

        STATUS = LIO$SET_I (&axv_id, &LIO$K_SYNCH, &0);
                 if(!(STATUS & STS$M_SUCCESS)) LIB$SIGNAL(STATUS);

/* Set up AXV11-C channel 2 for input. */

        STATUS = LIO$SET_I (&axv_id, &LIO$K_AD_CHAN, &1, &2);
                 if(!(STATUS & STS$M_SUCCESS)) LIB$SIGNAL(STATUS);

/* Set up a channel gain of 1. */

        STATUS = LIO$SET_I (&axv_id, &LIO$K_AD_GAIN, &1, &1);
                 if(!(STATUS & STS$M_SUCCESS)) LIB$SIGNAL(STATUS);

/* Trigger on LIO$READ and fill buffer as fast as possible. */
        STATUS = LIO$SET_I (&axv_id, &LIO$K_TRIG, &1, &LIO$K_IMM_BURST);
                 if(!(STATUS & STS$M_SUCCESS)) LIB$SIGNAL(STATUS);
```



DEC REALTIME INTEGRATOR MAKES IT SIMPLE.

With DEC Realtime Integrator, you can be working with results in the time it takes you to wrestle with syntax errors. Because as a complete graphical programming environment for realtime data acquisition and testing, it makes building an application as simple as drawing a picture.



And since DEC Realtime Integrator is open, it lets you work the way you want to work. It can be used with IEEE-488 and RS-232 instruments from any vendor – including Tektronix and HP – and runs on any Digital VAX or RISC platform. Plus it allows you to send data to your favorite analysis and report-writing packages.

For more information, including our free video "Realtime In No Time," call 1-800-DEC-RTI-1. And you'll see that setting up a test program doesn't have to be a test of your patience. digital™

DIGITAL. THE OPEN ADVANTAGE.

averaged with a selectable number of previous spectra and presented graphically as a "waterfall" display: this would be similar to a sonar display, which has been shown to enable a technician to detect discrete frequencies before an automatic system would detect them.

The bearing frequencies would be calculated from the measured speed and the known parameters of the bearings, with allowances for slip. The power-spectrum levels would be read for each bearing frequency; a moving average of the amplitude at each bearing frequency and harmonic would be maintained, and trends representing statistically significant increases would be identified by threshold detection and indicted graphically.

By use of algorithms based partly on analyses of data from prior tests, the results of both the kurtosis and power-spectrum calculations would be processed into predictions of the remaining operating time until failure. All the results would then be processed by an expert system. The final output would be a graphical display and text that would describe the condition of the bearing(s).

This work was done by Nathan B. Higbie of Technology Integration and Development Group, Inc., for **Marshall Space Flight Center**. *For further information, Circle 132 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 18]. Refer to MFS-26141.

Advanced Receiver for Phase-Shift-Keyed Signals

The receiver would track weak signals, extracting Doppler shifts and transmitted digital data.

NASA's Jet Propulsion Laboratory, Pasadena, California

The ARX II is the second "breadboard" version of an advanced receiver of phase-shift-keyed signals. Although the ARX II is being built for the reception of weak signals from distant spacecraft, it has several features that would also be useful in terrestrial digital communication systems. The basic overall functions required of the receiver are to measure the Doppler shift of the carrier signal and to detect the data symbols, with proper synchronization. The receiver must be versatile enough to track a residual, suppressed, or hybrid carrier and to demodulate a sinusoidal or square-wave subcarrier signal that is modulated by any of several types of phase-shift keying, including binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), offset quadrature phase-shift keying (OQPSK), or minimum-shift keying (MSK).

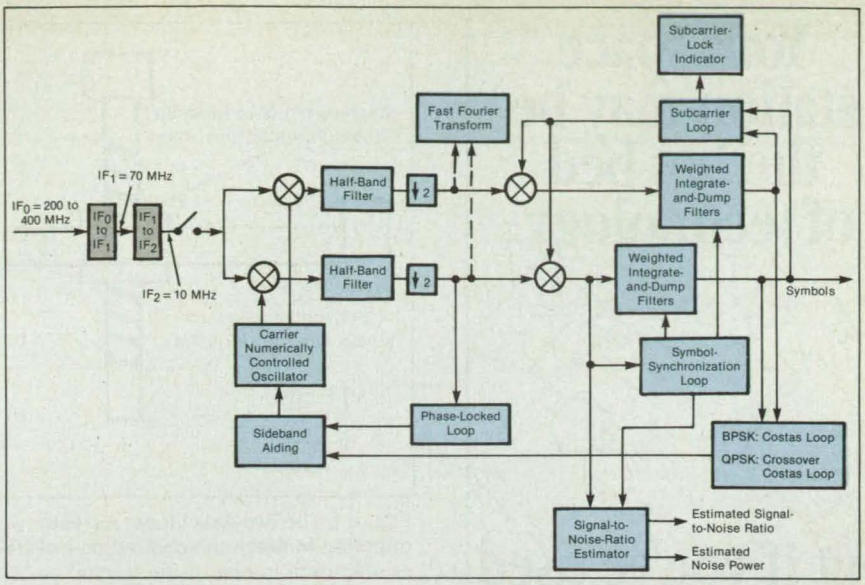
The receiver (see figure) includes an analog "front end" that performs mainly filtering and down-conversion operations. The remaining signal-processing part of the receiver is made of the latest commercially available digital circuitry. An incoming L-, S-, or X-band signal is first down-converted by an external subsystem to an intermediate frequency (IF_0) of 200 to 400 MHz, which is fed to the receiver. Within the receiver, the IF_0 signal is first down-converted to $IF_1 = 70$ MHz for finely tuned filtering, then to $IF_2 = 10$ MHz for sampling.

Because of the design requirement of a relatively high data rate of 6.6 megasymbols per second, the 10-MHz signal is sampled at about 40 MHz. The in-phase (I) and quadrature (Q) sampled signals are digitally mixed to baseband and processed

through half-band filters to remove the double-frequency terms. The baseband I and Q signals are then processed digitally to effect synchronization with the carrier, with the subcarrier, and with the symbols.

To satisfy requirements imposed by present and future external ranging equipment that is to be used with the receiver, the design provides for both analog and digital schemes for the closure of the residual-carrier-tracking loop. In the analog scheme, the 70-MHz signal is mixed with an 80-MHz phase-locked signal to produce the 10-MHz signal required at present. The analog-to-digital converter operates on this signal to produce 8-bit samples at 40 MHz. The 10-MHz IF_2 is then removed digitally by use of a lookup table. After filtering to remove the sum-frequency term, the resulting signal has an effective bandwidth of 10 MHz and a processing rate of 40 MHz.

The signal is then decimated by 2 to reduce the processing rate to the rate of 20 MHz required for Nyquist sampling. The Q samples are then accumulated to reduce the rate further to the update rate of the residual-carrier-tracking loop to enable a software implementation of the loop filter. The filter puts out an estimate of the frequency error at the update rate of this loop and adjusts the nominal frequency (4 MHz) of the numerically controlled oscillator. (The phase of this oscillator changes at the much higher rate of 20 MHz.) This feeds the digital-to-analog converter, the output of which is a 4-MHz sine wave. This sine wave is subsequently mixed with a fixed 84-MHz sinusoidal signal to produce the 80-MHz analog signal that closes the loop.



The **Advanced Receiver** is a hybrid digital/analog receiving subsystem that can extract symbols and Doppler shifts from a variety of weak phase-shift-keyed signals.

The digital scheme is similar except that in this scheme, the 80-MHz signal is a fixed reference signal and a numerically controlled oscillator running at 40 MHz with a 10-MHz nominal frequency is used instead of a lookup table. In both the analog and digital loop-closure schemes, conversion from analog to digital is performed at the 10-MHz IF_2 rather than at baseband, to avoid the potential for the generation of an erroneous dc bias. Moreover, the sampling frequency can be changed to 39.8 MHz to avoid any subharmonics of the sampling clock that might be generated by the analog-to-digital converter in the signal band of interest. A software command can switch the system between analog and digital closure without loss of lock on the carrier. However, the sampling frequency cannot be changed without disrupting operations.

This work was done by Sami M. Hinedi of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 165 on the TSP Request Card.*
NPO-18167

Compact Translating-Head Magnetic Memories

Stationary magnetic media would store information at densities up to 6.5 Gb/cm^2.

NASA's Jet Propulsion Laboratory, Pasadena, California

High-density memory devices of a proposed new type would combine some of the features of advanced rotating-disk magnetic recording and playback systems with features of compact two-axis high-acceleration linear actuators like those that plot graphical outputs of computers. The new devices would weigh less, occupy less space, and consume less power than disk and tape recorders do because there would be no need for the motors and associated mechanisms that rotate the disks and translate the tapes. Instead, the two-axis linear actuators would scan magnetic reading-and-writing heads across stationary rectangular magnetic sheets. Furthermore, whereas it is necessary to cope with angular momentum, rotational latency, and seek latency in a rotating-disk system, the head in a device of the new type could be translated across the data tracks directly to the desired location with minimal delay.

To minimize the mass, volume, and consumption of power, the control and the reading and writing electronics would be very-large-scale integrated circuits. Each recording head would include an inductive circuit and structure for writing and a magnetoresistive circuit and structure for reading. Because the amplitude of the output of a magnetoresistive sensor is independent of the scanning speed (unlike that of an inductive sensor, which is proportional to the speed), the problem of amplitude equalization in playback would be simplified greatly.

In the version shown in Figure 1, a dual recording head would be scanned in the y direction along a pair of parallel tracks, one of which would be dedicated to the stored data, the other of which would provide clock signals for synchronization of the data being read or written. (The clock signals could be prerecorded or written simultaneously with the first recording of data.) The embedded clock signals would enable the accommodation of varying scanning velocities, so that, for example, the actuators could operate in constant-velocity, constant-acceleration, or transient-acceleration modes (see Figure 2).

The magnetic storage medium would be a film of CoNi or other suitable cobalt alloy on a rigid metal, glass, or polymeric substrate. Because the head would be made to slide across the medium in contact during writing to minimize losses during subsequent reading, it would be desirable to protect the alloy film against abrasion. For example, one could deposit a hard, thermally conductive, protective film of diamondlike carbon on the alloy film by sputtering. The sliding surface of the scanning head could be protected similarly. Although contact recording is preferred to maximize the signal-to-noise ratio, the head could be contoured to provide an air bearing that would lift the head a small distance off the medium at high scanning velocities. In that case, the margins of the medium could be reserved for use exclusively as takeoff and landing zones for the head: this would limit wear to the margins, away from the central data-storage area.

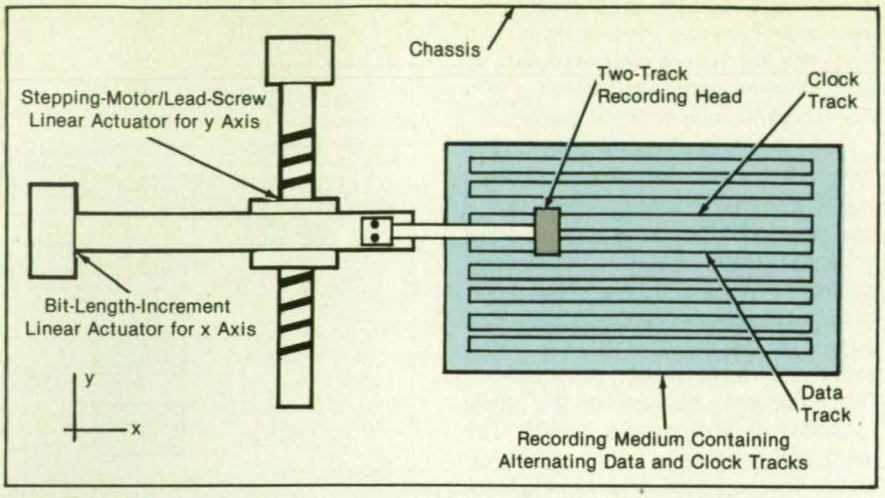


Figure 1. The **Two-Axis Linear Actuator** would move the two-track recording head in the *y* direction to reach the desired pair of tracks, then scan along the *x* direction to record or read data in one of the tracks.

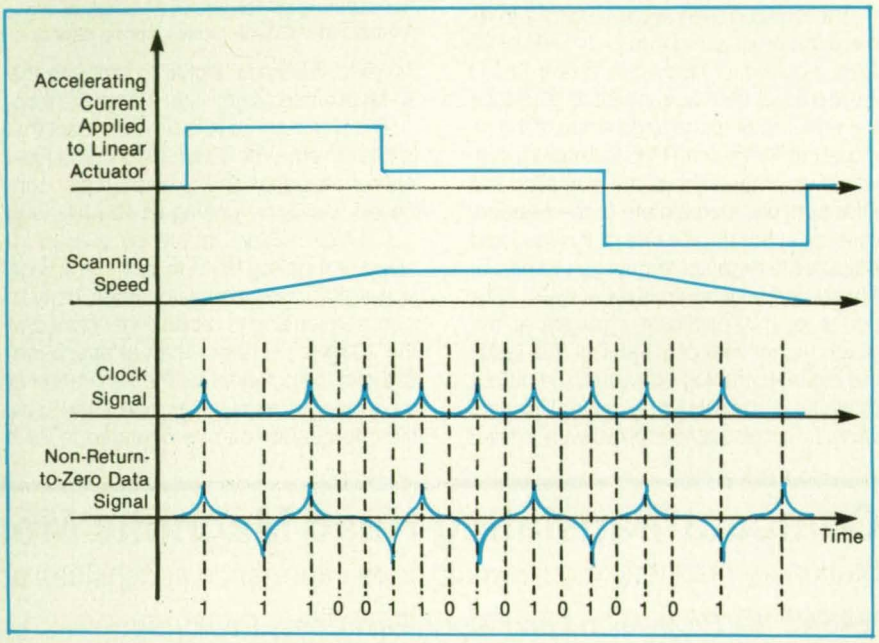


Figure 2. The **Clock Signal** read out by the sensor on the clock track would synchronize the processing of the data signal read out by the head on the data track, despite variations in scanning speed.

Typical anticipated performance figures are based on extrapolations from recent advances in magnetic-recording and linear-actuator technology. Storage densities could be as high as 1 Gb/in.^{2} (6.5 Gb/cm^2) with bit lengths of about 0.15 μm and track widths near 3.5 μm. A head moving at a speed of 30 in./s (75 cm/s) could read or write data at a rate of 5 Mb/s.

This work was done by Romney R. Katti of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 78 on the TSP Request Card.*
NPO-18218

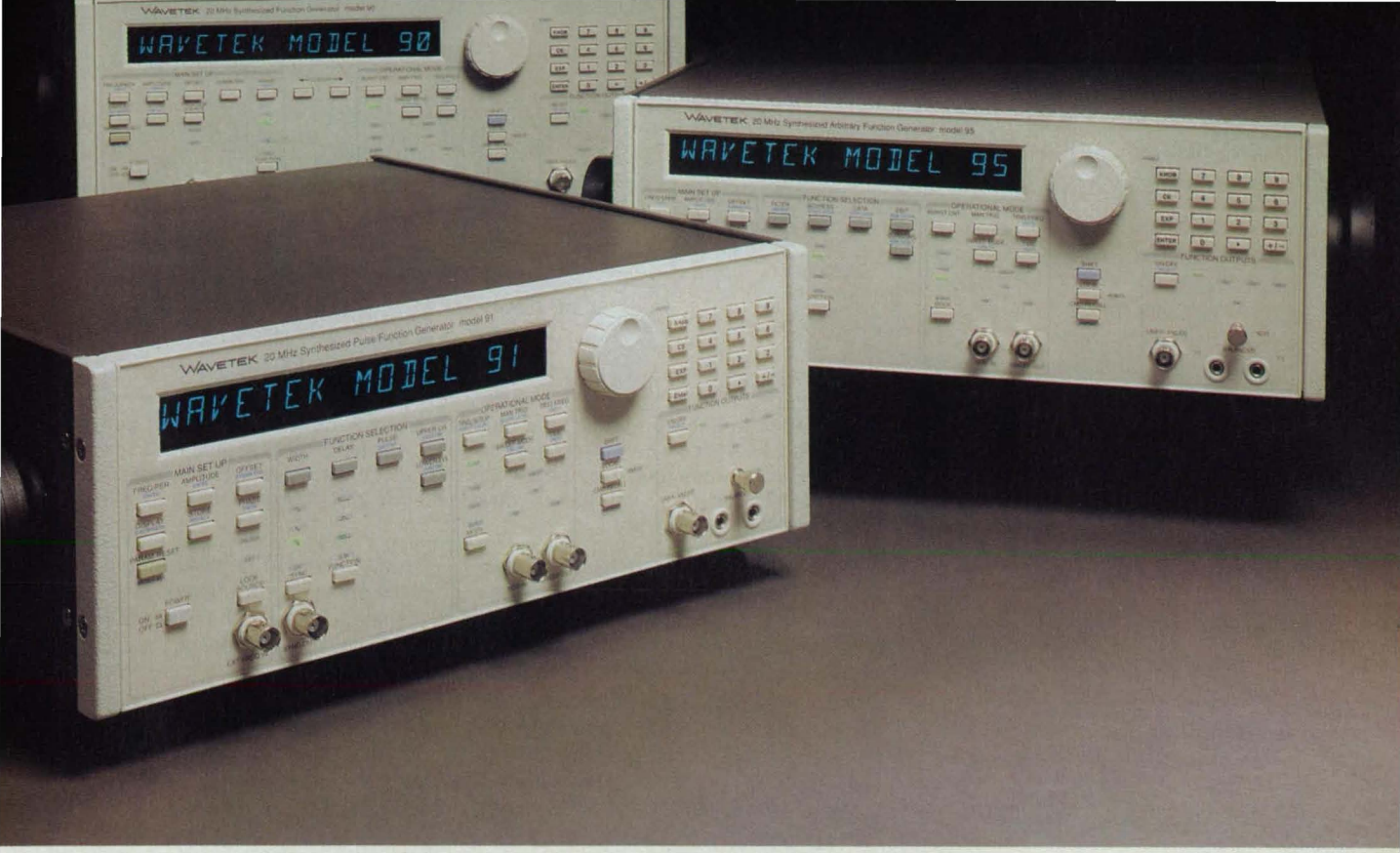
Tracking Retroreflective Targets on a Structure

Locations of targets are measured repeatedly.

NASA's Jet Propulsion Laboratory, Pasadena, California

An optoelectronic system simultaneously measures the positions of as many as 50 retroreflective targets within a 35° field of view, with an accuracy of 0.1 mm. The system repeats the measurements 10 times per second. The system gives an unambiguous indication of the distance to each target that is not more than 75 m away from its sensor module.

SHAPES fills a current need in the areas



Our Model 91 will make your pulse race and help you function better.

Introducing the latest member of the 90 Series family: Model 91 Synthesized Pulse Function Generator. It delivers functions and pulses to 20 MHz with five digit frequency accuracy and has even faster pulse rates out the rear: 50 MHz, plus a 100 MHz clock rate. Choose ECL, CMOS or TTL levels, or set your own.

The functions and pulses can be swept or modulated, and there is even GPIB programmability. Plus an external frequency input that lets you use the Model 91 as a frequency counter.

With all these capabilities, Model 91 redefines the concept of an all-purpose benchtop instrument.

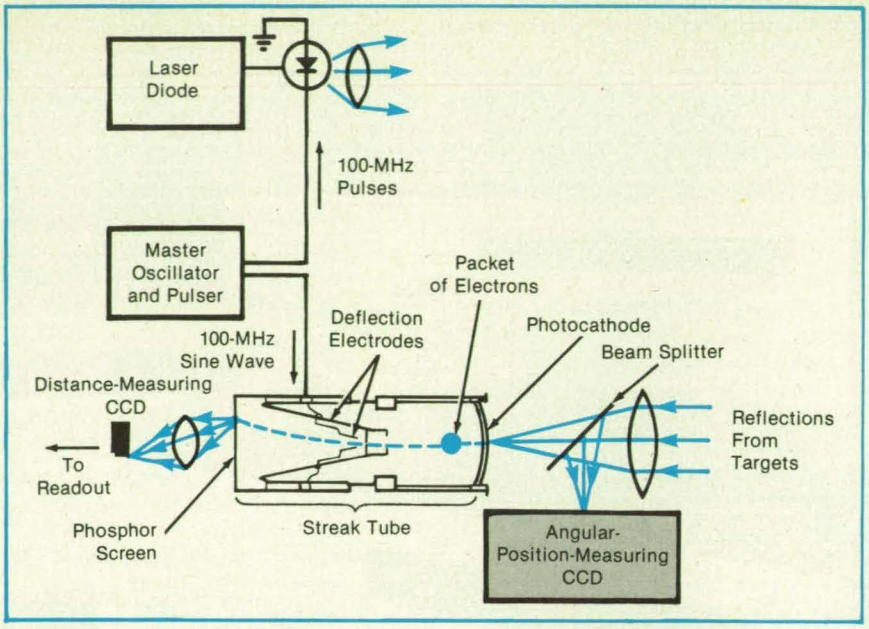
About all it doesn't do is generate arbitrary waveforms, but there's the Wavetek Model 95 Synthesized Arbitrary Function Generator for that.

Of course if you want even greater pulse generation capability, our four-channel Model 869 is among the most accurate pulse generators in the world.

For more information about our multi-purpose function generators, high performance pulse generators, or test development and arbitrary waveform software, call Wavetek at 1-800-874-4835.

For Literature Circle No. 395
For A Demo Circle No. 396

WAVETEK



The Distance to Each Target is determined by a streak tube, in which light pulses reflected from a target are converted into packets of electrons that are deflected according to the delays between transmission and return of the pulses. Meanwhile, a beam splitter diverts reflections from a continuous-wave laser into a CCD video camera for measurement of angles of reflection.

of system identification and control of large flexible structures, such as large space- and ground-based antennas and elements of earth-orbiting observational platforms. It is also well suited to applications in rendezvous and docking systems. Ground-based applications includes boresight determination and precise pointing of the 70-m Deep Space Network antennas.

The system is called SHAPES for "spatial, high-accuracy, position-encoding sensor." It illuminates the retroreflective targets by means of a set of lasers in its sensor module. In a typical application (see figure), a laser diode illuminates each target with 30-ps pulses at a repetition rate of 100 MHz. Light reflected from the target is focused by a lens and passed through a beam splitter to form images on a charge-coupled device and on the photocathode of a streak tube. The angular position of the target is determined simply from the position of its reflection on the charge-coupled device.

The measurement of the distance to the target is based on the round-trip time of the optical pulses. The round-trip time or the distance can be measured in terms of the dependence, upon distance, of the difference between the phase of the train of return pulses incident on the photocathode and the phase of a reference sine wave that drives the deflection plates of the streak tube. This difference, in turn, manifests itself as a displacement between the swept and unswept positions, at the output end of the streak tube, of the spot of light that represents the reflection from the target. The output of the streak tube is focused on a charge-coupled device for measurement and processing of the position of this spot. Three microprocessors control the operation of the SHAPES and convert the raw data acquired from the angular-position and distance-measuring charge-coupled devices into positions of targets in three dimensions.

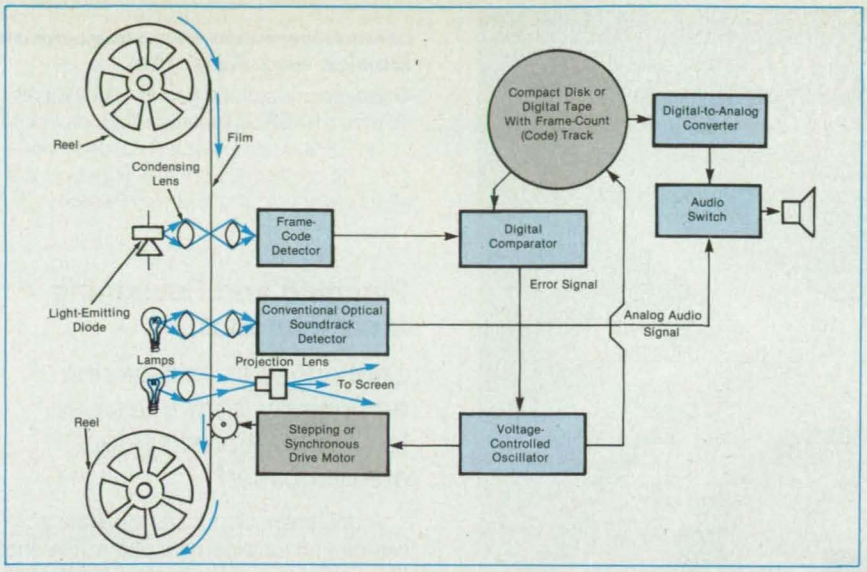
This work was done by Noble M. Nerheim, Mark D. Nelson, and Randel Blue of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 125 on the TSP Request Card.*
NPO-18204

Enhancing Soundtracks From Old Movies

A synchronized compact disk would play back digitally enhanced audio.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed system would enhance the soundtracks of old movies. The signal on the optical soundtrack of a film would be digitized and processed to reduce noise and otherwise improve its quality; timing signals would be added, and the signal would be recorded on a compact disk, from which the enhanced sound would be played back in synchronism with the film (see figure). Digital audiotape could be



The **Digital Comparator and Voltage-Controlled Oscillator** synchronizes the speed of the film-drive motor and compact disk motor. A frame-code detector would read binary frame-identifying marks on the film. The digital comparator would generate an error signal if the marks on the film did not match those on the compact disk.

used instead of a compact disk as the sound-recording medium.

The system was conceived to preserve and enhance the sound on archival aeronautical films but can be used as well for commercial films. Motion pictures recorded on nitrate film are deteriorating rapidly. Transferring them to more stable acetate or polyethylene terephthalate film helps to preserve the images but does nothing to improve the sound, which has the original poor quality and contains additional noise contributed by scratching and aging of the film.

According to the concept, a series of binary numbers would be recorded on the new film, one to identify each frame. A corresponding series would be recorded on the compact disk. The system would repeatedly compare the frame-identifying numbers on the film and compact disk. If the film and compact disk were automatically started together (for example, if the starting frame on the film were used to trigger the start of the compact disk) and if the speed of both were synchronized with the powerline frequency or with a common clock, they would continue to play together if neither were disturbed. In that case, the frame-identifying number on the film would match that on the compact disk, and a digital comparator in the system would not command any change. If, however, the film had been broken and spliced (with consequent loss of a small length), the comparator would observe a mismatch when the splice passed by the frame-code detector. The comparator would then send an error signal to a voltage-controlled oscillator, which would command the film drive to speed up to restore synchronism. The comparator would return the film drive to its normal speed once synchronism was restored.

The speed of the compact disk would not be altered to make this adjustment. Thus, no variation in the speed of playback (called "wow" in the industry) would be audible. Conversely, the CD could be slowed down slightly within limits imposed by "wow." In the unlikely event that the compact-disk player skipped a track (possibly if it were bumped), it might be necessary to change the speeds of both the disk and the film to restore synchronism. In such a case, the compact-disk sound could be turned off temporarily, and sound would be played back from a rerecorded backup optical soundtrack on the film until synchronism was restored.

This work was done by Robert E. Frazer of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 14 on the TSP Request Card.*
NPO-17797

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Planning and Reasoning for a Telerobot

Challenges in transferring technology from a testbed to an operational system are discussed.

A document discusses the state of research and development of the Telerobot Interactive Planning System (TIPS). The system, designed to provide planning and reasoning for telerobots, has been installed in the telerobot testbed at NASA's Jet Propulsion Laboratory. The planning-and-reasoning technology is to be transferred to Goddard Space Flight Center for use in NASA's first operational-flight telerobot.

When fully developed, telerobots will have both robotic and teleoperator capabilities. The first telerobot, the Flight Telerobotic Servicer, will include a base site on the Space Shuttle or Space Station and a remote site at a workplace, which may be an external structure being built on the Space Station or a satellite that needs servicing.

The goal in the development of the TIPS is to enable it to accept such instructions from an operator as the command to replace a given module, then to command a run-time controller to execute operations that will execute the instructions. The run-time controller plans fine motions, grasps, compliant motions, and applications of force and maintains a geometric data base of objects in the workspace. If the run-time controller encounters problems, the TIPS must modify its commands to overcome them. When the TIPS fails, it must allow the operator to take over.

The report presents the technical problems and describes the approaches that have been developed to solve them. It describes the prototype TIPS. Finally, it compares the prototype with the architecture it must support in the Flight Telerobotic Servicer.

This work was done by Stephen F. Peters, David S. Mittman, Carol E. Collins, Jacquelyn S. O'Meara Callahan, and Mark J. Rokey of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Planning and Reasoning in the JPL Telerobot Testbed," Circle 2 on the TSP Request Card.*
NPO-18287

Physical Sciences

Combined Velocity/Charge-to-Mass-Ratio Analyzer

Features include compactness, light weight, and low power.

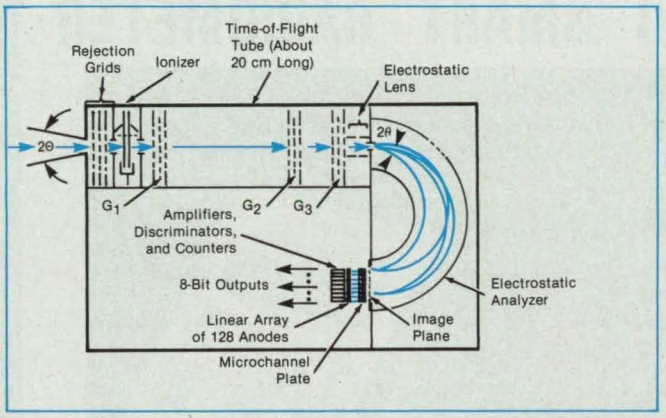
NASA's Jet Propulsion Laboratory, Pasadena, California

The instrument shown schematically in the figure is a combination of (1) a time-of-flight analyzer that selects charged particles traveling at and near a certain velocity and (2) a hemispherical electrostatic analyzer that sorts the velocity-selected particles according to the ratio between kinetic energy and electric charge ($mv^2/2q$). Because all the particles have nominally the same velocity, in effect the electrostatic analyzer can be regarded as sorting according to the ratio between mass and charge, m/q. The instrument is designed to be compact, to be light in weight, and to consume little power because it is intended for use aboard a spacecraft in analyzing ions, atoms, and molecules in planetary ionospheres and magnetospheres. Terrestrial versions would be useful in chemical analysis, chromatography, and analysis of plasmas.

The incoming ions, atoms, or molecules first pass through four rejection grids, one of which is biased at +1,000 V to reject positive ions if it is desired to detect negative ions (or at −1,000 V to reject electrons and negative ions if it is desired to detect positive ions). When it is desired to detect neutral atoms or molecules, the rejection grids are biased alternately positive, ground, negative, ground to reject both positively and negatively charged incoming particles, and an electron-beam ionizer is turned on to charge the desired neutrals for downstream sorting by the time-of-flight and electrostatic analyzers.

A train of pulses is generated by power metal oxide/semiconductor field-effect transistor switches and applied to shuttering grid G_1 to admit pulses of ions to the time-of-flight tube, and a suitably trained similar train of pulses is applied to grid G_2 to allow those ions that have the desired velocity to leave the time-of-flight tube and enter the electrostatic analyzer. Another, further delayed similar train of pulses is applied to grid G_3 to block ions traveling at undesired subharmonics of the desired velocity. These shutters act as synchronized "traffic lights" to define the ion velocity. Each shuttering grid is sandwiched between two grounded grids to prevent coupling of the shuttering pulses into the ionizer and electrostatic analyzer. The shuttering pulses are about 10 ns long, 400 V in amplitude, and the two delays between the three pulse trains can be adjusted independently in the range of 1 to 100 μs.

At the exit of the time-of-flight tube, the ions are focused through an electrostatic lens system into the electrostatic analyzer. The electric field generated by the application of a suitable voltage between the inner and outer hemispheres of the analyzer causes the ions to travel on curved paths. Each path ends on an image plane at a position that depends on $mv^2/2q$. The ions strike a microchannel-plate electron multiplier, and the resulting pulses of secondary electrons are detected by a linear array of 128 anodes. The output of each anode is counted and recorded.



This **Instrument Analyzes Ions** according to velocity and ratio of mass to electric charge. It is a state-of-the-art combination of two well-established instruments: a time-of-flight analyzer and an electrostatic analyzer functioning as a mass spectrometer.

This work was done by Ara Chutjian, Otto J. Orient, and Mark T. Bernius of Caltech and R. Richard Hodges of the University of Texas at Dallas for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 77 on the TSP Request Card.*

NPO-18085

Modeling Optics for Analyses of Dynamics and Controls

Ray-tracing models of optics can be integrated into models of systems.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method for computing the optical sensitivities of single- and multiple-element optical trains has been developed for use in analyses of the dynamics of optoelectromechanical systems. A system of the type in question typically includes controlled optics (e.g., lenses, mirrors, prisms, and/or gratings mounted on electromechanical actuators) supported by a flexible structure. As used here, "optical sensitivity" denotes a ratio between a perturbation in the optical output of the system (e.g., a change in the direction of an output ray or a displacement of an output wave front) and an input perturbation (e.g., a small mo-

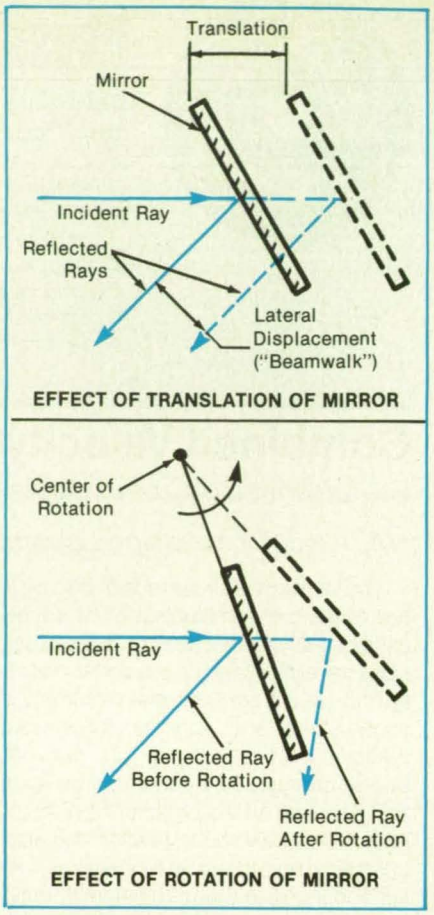
tion of a refracting or reflecting surface or a change in the direction of an input ray).

The method is based partly on the established techniques of ray tracing and partly on a matrix representation of each surface of each optical element. A complete optical system that includes mirrors, lenses, focal planes, and other elements is specified by use of a few simple parameters in a single coordinate frame. One or many input rays are specified, and the propagation of these rays along the optical train is computed exactly. In a line-of-sight model of the optical train, a single ray (e.g., the chief ray) is thus traced to represent the first-order aiming effect of the optical train upon the beam. In a wavefront model of the optical train, multiple rays are traced to construct a wavefront at any given reference surface. The wavefront could then be represented, for example, in terms of a series of aberration functions or a figure of merit.

For linear modeling, the exact rays represent nominal conditions about which perturbations are calculated. For each optical element treated initially as an isolated optical system, the first-order sensitivities of the direction and lateral displacement of the output beam and of optical-path length to changes in the direction and lateral displacement of the input beam and movements of each optical element (see figure) are computed and expressed in matrix form. The resulting sensitivity matrices for the elements are chained to compute the overall first-order sensitivities of the system.

Linear and nonlinear mathematical models of the optical train can be integrated into a mathematical model of the dynamics of the structure and of the control system. The sensitivity matrices from a linear model can be used to determine the controller gains that relate the sensed optical errors to the deflections of the actuators on which the optical elements are mounted. These gains are computed by projecting the sensitivity matrices onto specific actuator and sensor coordinates, then inverting.

The sensitivity matrices can also be used to derive equations for use in analysis of errors and calibration of instruments. Error models are created by propagating the effects of structural and other misalignments to the optical elements by use of conventional transformations, then propagating the effects to focal planes by use of the sensitivity matrices as optical trans-



Translation or Rotation of a Mirror changes the lateral position of the reflected ray and the length of the optical path along the incident and reflected rays. Rotation also changes the direction of the reflected ray.

AMCOBILITY wraps it up beautifully.

If it's electronic, Amco can package it. We've got enclosures for every size and shape, designed and built with a fanatical obsession for quality.

Big claims? Yes, but we've got big experience: nearly a half century in applications as demanding as space probes and missile launchers.

AMCOBILITY also brings high quality and high style together. We make your systems look as good in real life as they looked on the drafting table.

That wraps it up: quality, style, selection and service. Call for Amco's Full Line catalog, with complete specs and loads of application information. See how beautifully AMCOBILITY can wrap up your enclosure needs!

Approved GSA Supplier Contract# GS-07F-3494A

AMCO®

AMCO Engineering Co.

3801 North Rose Street
Schiller Park, IL 60176-2190
Illinois: 708-671-6670 **For More Information**
FAX: 708-671-9469 **Circle No. 500**

Call Toll Free: 1-800-833-3156

See Us At Electro, Boston, MA 5/12 - 5/14 Booth #1415 - 1417; ICA Expo, Atlanta, GA 5/19 - 5/21 Booth #1705

formations. These error models are used to determine the effects of errors on the accuracy of aiming and of control of the optical path. The error equations can also be used in a sequence of known observations to calibrate the modeled sources of error.

This work was done by William C. Breckenridge of Caltech and David C. Redding of Charles Stark Draper Laboratory for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 42 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-18194.

Mapping Microwave Fields With Thermal Paper

A simple experimental technique is extended to obtain some vector information.

NASA's Jet Propulsion Laboratory, Pasadena, California

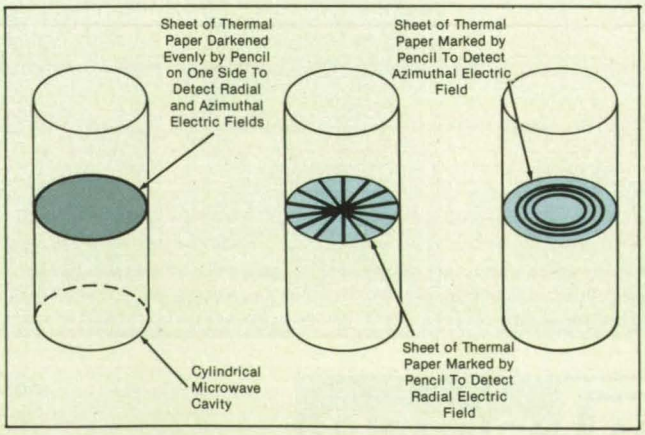
A simple, inexpensive technique can be used to map the direction and, to some extent, the intensity of an electric field in a microwave resonant cavity. The technique is an extended version of the well-established technique of using thermal paper to map intensities (only) of microwave fields.

The only special material required to implement the technique is heat-sensitive paper like that used in thermographic copiers. Using the side of a pencil, one coats one face of the paper with graphite. One then places the paper in the microwave cavity, where the electric field gives rise to electric current in the graphite. The current heats the graphite, the local heating-power density being proportional to the square of that component of the electric field that lies in the plane of the paper. As a result, the paper is darkened with a pattern that represents the time average of the square of the electric field in the plane of the paper.

To extend this technique to show the directional characteristics of an electric field within the plane of the paper, one scribes pencil lines that lie along the desired coordinate axis or axes. The separation between the lines prevents current flow perpendicular to the lines, and only that component of the electric field that lies along a line can heat the paper and discolor it along that line.

For example, suppose that one wishes to map radial and azimuthal fields in the plane perpendicular to the axis at the midlength of a round cylindrical resonator. For this purpose, two circular pieces of thermal paper are needed — one marked with radial lines, one marked with azimuthal lines. The paper circles are placed in the plane in question and exposed to the microwave field (see figure). To make the example more specific, suppose that an electromagnetic field in the TE 011 mode is excited in the cavity. The electric field in this mode has only radial components. Consequently, only the sheet marked with radial lines is darkened; the sheet marked with azimuthal lines remains unchanged.

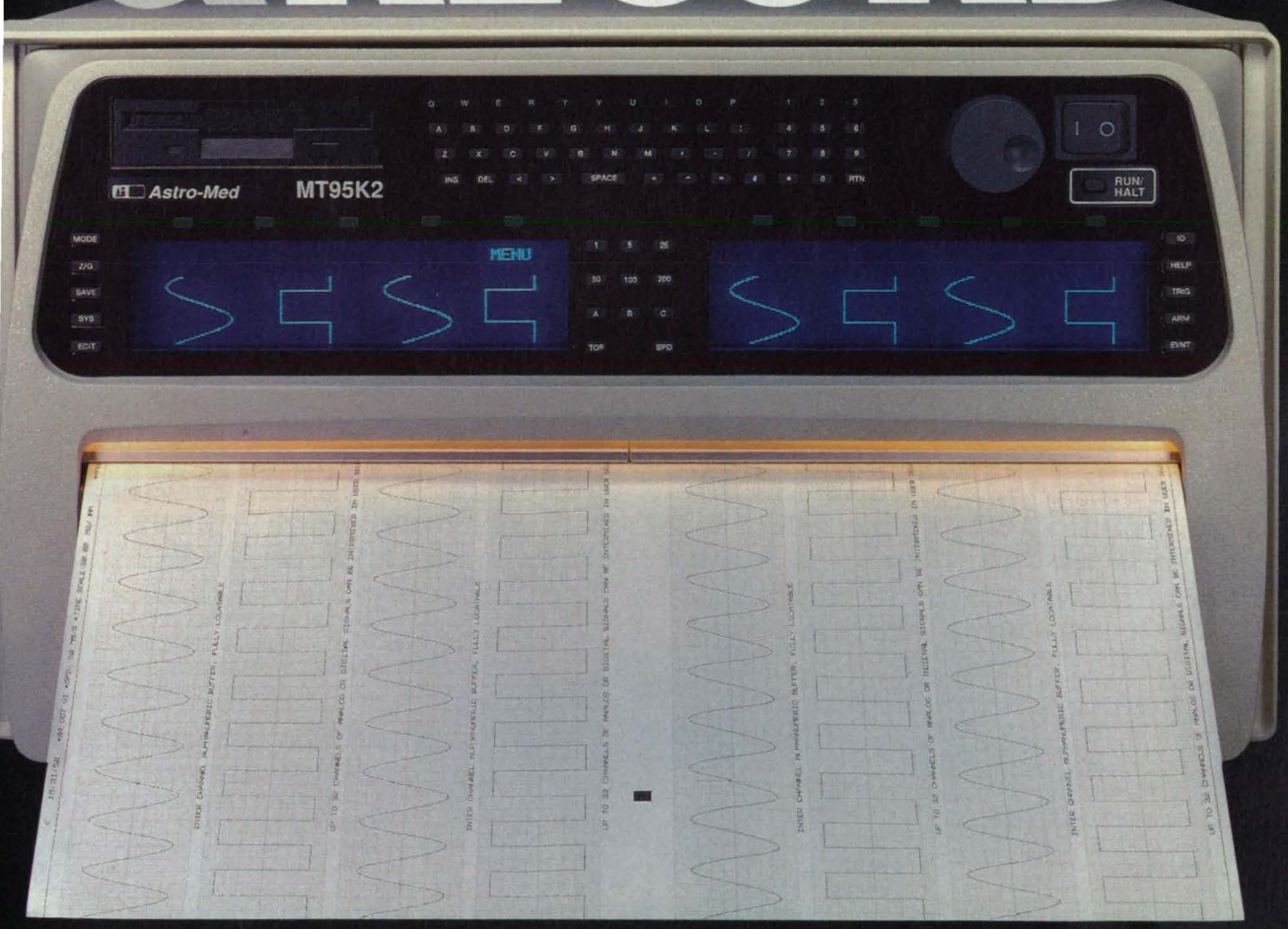
This work was done by John L. Watkins of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 148 on the TSP Request Card.*
NPO-17944



Sheets of Thermal Paper, either darkened evenly by pencil or scribed with pencil lines, are placed in a microwave cavity to obtain qualitative data on the intensity and direction of the electric field.

THE ALL NEW ASTRO-MED

MONITOR & RECORD



No Delay...see full traces on monitor while recording!

Personal Chart Setups with on-board floppy drive

Data Capture...up to 32 megabytes in RAM; 120 megabyte internal hard drive; stream to external drive via SCSI

8 to 32 Waveform Channels...plus 64 events; DC to 20 kHz; chart speeds to 500 mm/sec

Laser Printer Chart Resolution...300 dpi; clear, crisp traces

t simply, the MT95K2 is another major Astro-Med ovation in "chart recording": you can preview your data, record it, store it, play it back, send it to disk for analysis, record it again, and more! Whether you need a basic 8 channel recorder or a sophisticated 32 channel recording system, the MT95K2 is the perfect platform for you today.

Call, Fax, or write for details!

Astro-Med, Inc.®

Astro-Med Industrial Park, West Warwick, Rhode Island 02893
Phone: (401) 828-4000 • Toll Free (800) 343-4039
Fax (401) 822-2430 • Telex 710-382-6409

Sales and Service Centers in London, Paris, Frankfurt and Milan

Injection Seeding of a Q-Switched Alexandrite Laser

Bandwidth was narrowed from 750 GHz to 180 MHz.

Goddard Space Flight Center, Greenbelt, Maryland

An experiment has demonstrated that a standing-wave, Q-switched, tunable alexandrite laser can be injection-seeded to increase the stability of its output frequency and significantly reduce its bandwidth. When injecting seeding is effective, the injecting or seed laser acts as an oscillator or master, while the Q-switched laser into which output of the seed laser is injected acts as an amplifier or slave. This master/slave effect can occur when the Q-switched laser has been tuned so that the spectrum of the injected beam lies within its passband. The lasing frequency of the Q-switched laser becomes locked to the seed frequency by depletion of the gain from outlying modes of the Q-switched laser into the few of its modes that surround the seed frequency before those outlying modes attain sufficient energy to lase.

In the experiment (see Figure 1), the seed beam was a single-mode, continuous-wave beam from a stabilized AlGaAs laser diode with a wavelength of 765 nm and a bandwidth of <200 MHz. Two Faraday rotators that yielded a combined isolation of 64 dB were used to protect the laser diode from feedback from the Q-switched alexandrite laser. To obtain maximum transmission through the rotators, the beam emerging from the diode was first collimated and reduced to a smaller diameter. The seed beam was then turned by two mirrors and injected into the Q-switched laser through a 60-percent-output coupler.

The Q-switch was used to start the lasing action of the alexandrite laser in the normal manner; i.e., no modifications to the basic Q-switch operation of the slave laser were required. The alexandrite laser was tuned to 765 nm by use of a two-plate birefringent tuner that had a bandwidth of 750 GHz — considerably greater than the bandwidth of the seed beam. A 0.5-m monochromator was used to monitor the wavelengths of both lasers. The bandwidth was

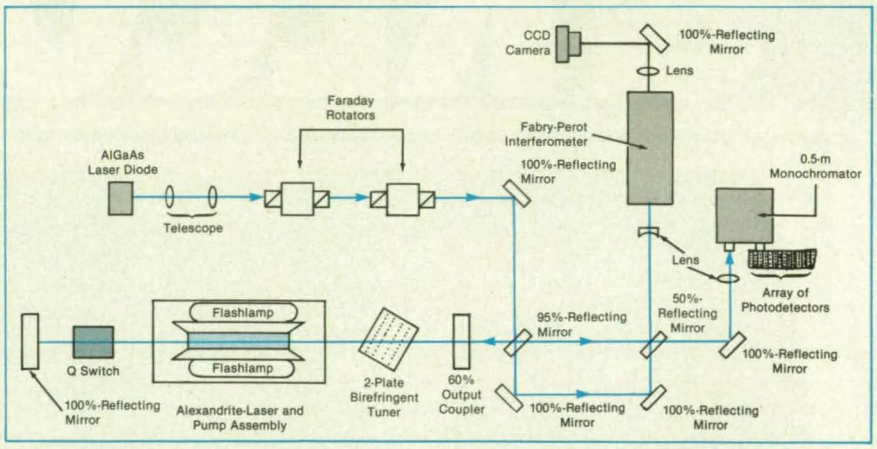
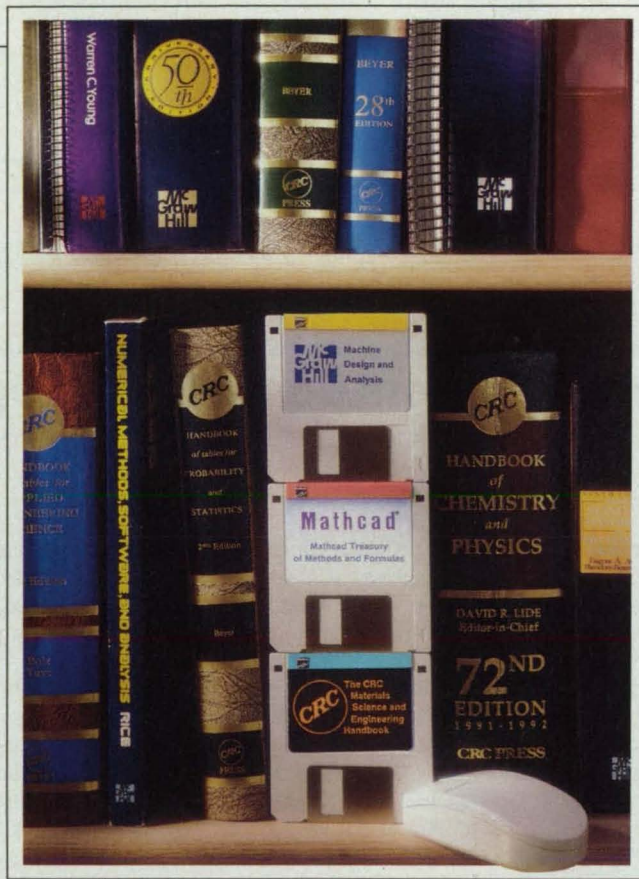


Figure 1. The **Q-Switched Alexandrite Laser** was injection-seeded by the continuous-wave beam from the stabilized AlGaAs laser diode.

Your favorite technical handbooks are now available in soft editions.



A new approach to math.

Introducing the Mathcad 3.1 Software System for Microsoft Windows or UNIX. It revolutionizes math by letting you zip through problems naturally and logically—because it works the way you think. And now it's even more powerful, thanks to new Electronic Handbooks.™

PC MAGAZINE EDITOR'S CHOICE
Mathcad 2.5
3-14-89 issue.
Best of '88
Best of '87

More than a number-cruncher.

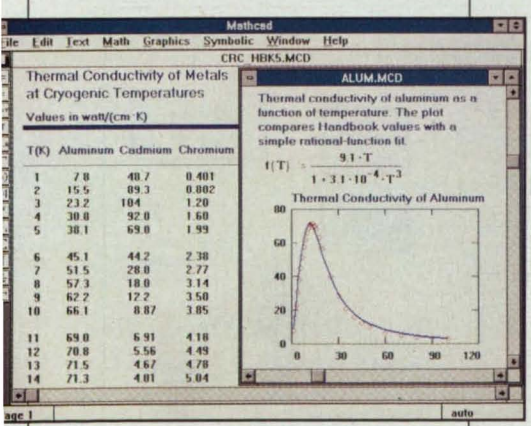
With Mathcad 3.1, you type your work anywhere into the live screen—just like you'd write on a scratchpad—and Mathcad does the calculating. Updates answers when a variable changes. Even graphs in 2-D or 3-D.

Symbolic calculation capabilities let you do integrals, Taylor series, or infinite sum calculations with click-n-drag simplicity.

And when you're done, Mathcad prints out presentation-quality documents complete with equations in real math notation.

Fast electronic access to commonly used methods, formulas and diagrams.

Mathcad's new Electronic Handbooks give you instant access to the formulas, methods, diagrams and tables you rely on every day. Just open an Electronic Handbook and select your topic. They're interactive, so you can modify formulas for specific calculations. Change parameters, plots and variables, and let Mathcad automatically calculate your answers within the Handbook. Or double-click on a Handbook entry and paste it into your Mathcad document—with the correct units!



Three new optional Mathcad Electronic Handbooks* are now available, each created in conjunction with a leading publisher of technical reference handbooks:

- **Mathcad Treasury of Methods and Formulas** offers you a host of the methods, formulas and diagrams you use every day, along with interactive explanations of every feature and algorithm of Mathcad.
- **Machine Design and Analysis** from Hicks' *Standard Handbook of Engineering Calculations* from McGraw-Hill, contains more than 125 practical calculation procedures including shaft and gear mechanics, time and power to cut, drill, bore, countersink, and a lot more.
- The CRC **Materials Science and Engineering Handbook** contains more than 140 tables of data, bit-mapped illustrations, and Mathcad plots. Includes densities, melting points and crystal structures of elements, properties of ceramics and superconducting materials, and much more.

PC MAGAZINE THE BEST OF 1991 COVER STORY

Also Available:

- **Optional Applications Packs**—adaptable Mathcad templates for Electrical, Mechanical, Civil and Chemical Engineering, Statistics, Advanced Math, and Numerical Methods.
- PC DOS and Macintosh® versions also available.

Free demo disk.

For a FREE Mathcad demo disk, or upgrade information, call 1-800-MATHCAD (or 617-577-1017, Fax 617-577-8829). Or see your software dealer.

UNIX Version now available

*Electronic Handbooks require Mathcad 3.1 and Microsoft Windows 3.0 (or higher) or UNIX.

1-800-MATHCAD

The answer is Mathcad®

NTB 22

MathSoft, Inc. 201 Broadway, Cambridge, MA 02139 USA • Phone: 1-800-628-4223 • 617-577-1017 • Fax: 617-577-8829

Australia: Hearne (03) 866 1766; Belgium: SCIA 013/55 17 75; Denmark: Engberg 42 25 17 77; Finland: Zenex 90-692-7677; France: ISE (1) 46 09 24 00; Germany: Softline (0 78 02) 4036; Italy: Channel 02-90091773; Japan: CRC 03-3665-9741; Netherlands: Klaasing 01620-81600; Sweden: AkademiData (018) 24 00 35; Switzerland: Redacom 032 41 01 11; U.K.: Adept Scientific (0462) 480055. In other locations, contact MathSoft, USA.

measured by use of an air-gap Fabry–Perot interferometer.

When the alexandrite laser was operated without injection seeding, its bandwidth was >750 GHz. When it was injection-seeded, its frequency shifted from the middle frequency of the birefringent tuner to the seed frequency, and its bandwidth decreased to less than 180 MHz as shown in Figure 2. When the seed beam was present but the birefringent tuner was adjusted so that its passband did not include the seed frequency, the alexandrite laser operated in a multitude of modes that had high gain, and seeding did not occur.

This work was done by Barbara J. K. Zukowski, Thomas R. Glesne, Geary Schwemmer, James P. Czechanski, and Richard B. Kay of **Goddard Space Flight Center**. *For further information, Circle 48 on the TSP Request Card.* *GSC-13365*

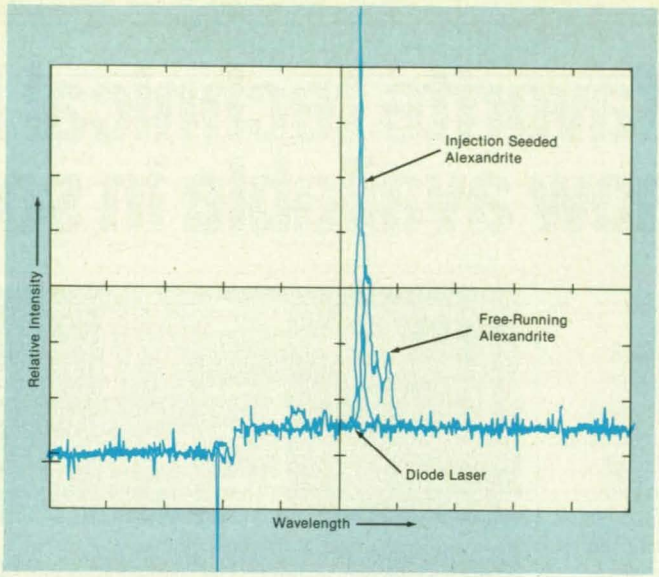


Figure 2. The **Spectrum of an Alexandrite Laser** was narrowed considerably by injection seeding.

Polarization-Rotating Sensors Connected to Optical Fibers

Features would include light weight, fast response, and immunity to electromagnetic interference.

NASA's Jet Propulsion Laboratory, Pasadena, California

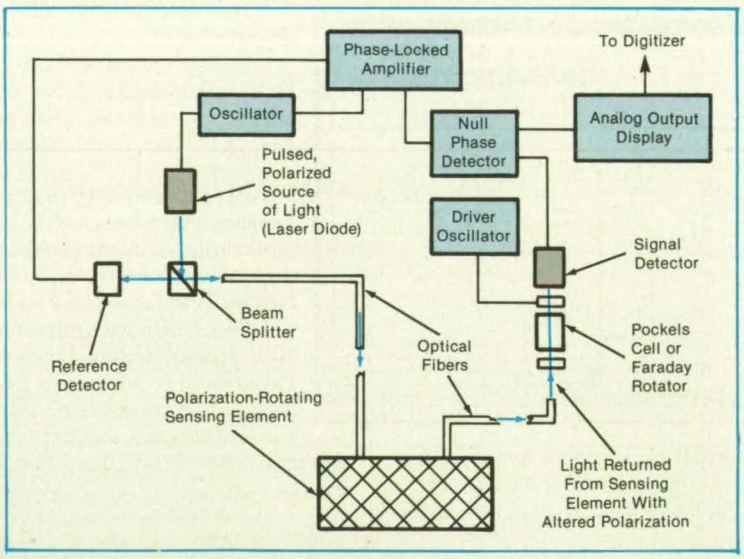
Optoelectronic sensor systems of a proposed new type would include polarization-rotating sensing elements interrogated by polarized light transmitted to and from the sensing elements along optical fibers. Included in this concept are sensing elements in which the polarization of light would be altered by various combinations of inherent birefringence, stress-induced birefringence, and Faraday rotation. Examples of such elements include displacement-measuring wedges, stress- or strain-measuring coils of optical fiber, and magnetic-field-measuring coils of optical fiber, respectively. Systems of this type offer several advantages, including light weight, fast response, immunity to electromagnetic interference at radio and lower frequencies, and no need to supply electrical power to the sensing elements.

In a representative system (see figure), the interrogating light would be polarized light from a laser diode. The diode could operate continuously or could be pulsed for low-noise ac operation with optional phase-locked detection. The basic idea is to measure the difference between the angles of polarization of the light returned by the sensing element and the light incident on the sensing element. In practice, this would usually entail comparing polarizations at the input/output end of the connecting optical fiber(s) remote from the sensing element and attempting to compensate for spurious components of rotation induced by the connecting optical fibers.

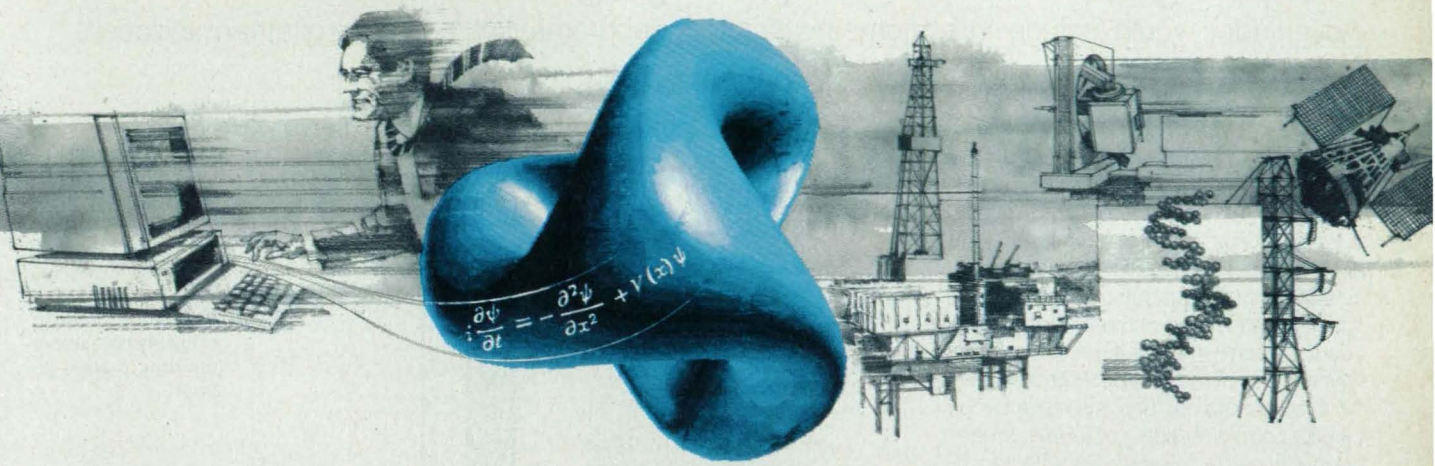
The difference between the polarizations would be compared by a dynamic nulling feedback technique in which the polarization of the returned light would be rotated back to that of the interrogating light by a Pockels cell or a Faraday rotator: the amount of rotation would be related to the signal applied to the rotator, and this signal would be adjusted continually in response to the difference signal to drive the difference toward zero. The rotation signal could be displayed in an analog mode and/or digitized for additional processing.

To prevent ambiguities, the maximum rotation should not exceed 180°. By use of the dynamic nulling technique, it is practical to resolve the full-scale rotation of 180° to 1,000 parts. To compensate for spurious rotation in the interrogating fibers, one could transmit reference signals in reference fibers, which would be placed alongside the interrogating fibers but not connected to sensing elements. Any rotation signal derived from the reference fibers would be subtracted from that derived from the interrogating fibers, under the assumption that the spurious components of rotation in both sets of fibers were equal. Thus, the net rotation signal would, in principle, represent only the component attributable to the sensing element.

This work was done by Robert E. Frazer of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 13 on the TSP Request Card.* *NPO-17591*



Polarized Light Would Be Transmitted to and returned from a sensing element along optical fibers. A nulling feedback system would measure the difference between the angles of polarization of the transmitted and returned signals.



The Principle Behind

axiom

the Scientific Computation System

Mathematicians, Physicists, Chemists, Engineers and Economists—anyone who knows the importance of symbolic solver software—should know about the new generation of mathematical software. Axiom takes users farther and faster into the universe of computational and visual mathematics.

But it's more than that!

Axiom breaks the barriers
In Axiom, you have access to high level interactive language interfaced with a comprehensive library of datatypes and polymorphic algorithm packages for scientific computation. Better yet, it's user extensible. You can define your own datatypes, functions, objects or macros.

Axiom—Power you can see
Look beyond Axiom's mathematical capability and you will find 2-D and 3-D visualization tools, plus the Hyperdoc system—a powerful online, help, tutorial and browser system that ensures you will make complete use of Axiom's capabilities.

What began as the "scratchpad" project at IBM's TJ Watson Research facility is available now as Axiom, the symbolic solver from the Numerical Algorithms Group.

The principle is simple: travel farther and faster in the realm of computational and visual mathematics.

But it's more than that!

To find out just how much more, call NAG today or circle the number below.

NAG NUMERICAL ALGORITHMS GROUP

NAG Inc, 1400 Opus Place, Suite 200, Downers Grove, IL 60515-5702, USA, Tel: 1 708 971 2337 Fax: 1 708 971 2706
NAG Ltd, Wilkenson House, Jordan Hill Road, OXFORD, OX2 8DR, UK, Tel: 44 865 511245 Fax: 44 865 310139
NAG GmbH, Schleißheimerstr. 5, D-8046 Garching bei Munchen, Deutschland, Tel: 49 89 3207395 Fax: 49 89 3207396

For More Information Circle No. 428

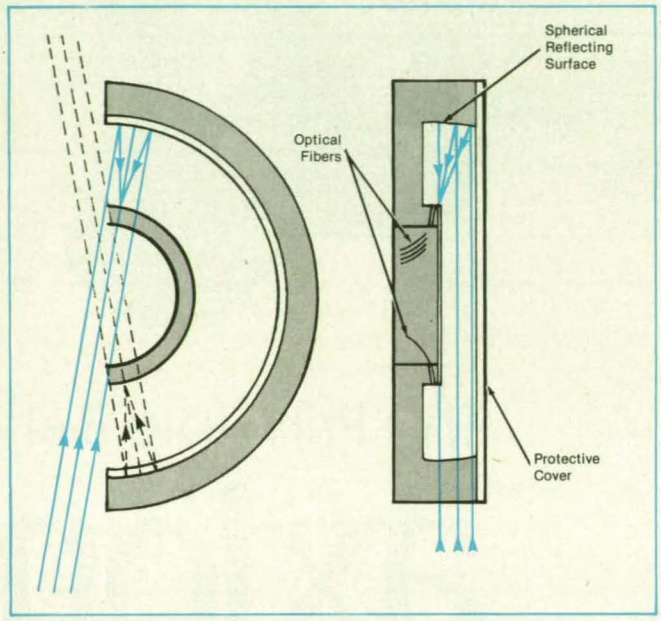
Wide-Angle, Reflective Strip-Imaging Camera

Advantages would include little geometric distortion, achromatism, and ease of athermalization.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed camera would image a thin, striplike portion of a field of view 180° wide. For example, it could be oriented to look at the horizon at all easterly directions from north to south or it could be rotated about its horizontal north/south axis to make a "push-broom" scan of the entire sky proceeding from the easterly toward the westerly half of the horizon. Potential uses for the camera include surveillance of clouds, coarse mapping of terrain, measurements of the bidirectional reflectance distribution functions of aerosols, imaging spectrometry, oceanography, and exploration of planets.

The imaging optic would be a segment of concave hemispherical reflecting surface placed slightly off center (see figure). Like other reflecting optics, it would be achromatic. The unique optical configuration would practically eliminate geometric distortion of the image. The optical structure could be fabricated and athermalized fairly easily in that it could be machined out of one or a few pieces of metal, and the spherical reflecting surface could be finished by diamond turning. In comparison, a camera with a "fish-eye" lens, which provides a nearly hemispherical field of view, exhibits distortion, chromatism, and poor athermalization.



A **Thin Segment of a Hemispherical Concave Reflector** would form an image from a 180° strip field of view onto optical fibers, which would transfer the image to a strip of photodetectors or to a spectrograph.

The image would be formed on a thin semicircular strip at half the radius of the sphere. A coherent bundle of optical fibers would collect the light from this strip and transfer the image to a linear or rectangular array of photodetectors or to the entrance slit of an imaging spectrograph. Provided that the input ends of the fibers were properly aimed, the cones of acceptance of the fibers would act as aperture stops; typically, the resulting width of the effective aperture of the camera would be about a third of the focal length (f/3).

The camera would operate at wavelengths from 500 to 1,100 nm. The angular resolution would be about 0.5°. In the case of an effective aperture of f/3, the camera would provide an unvignetted view over the middle 161° of the strip, with up to 50 percent vignetting in the outermost 9.5° on each end.

The decentration of the spherical reflecting surface is necessary to make room for the optical fibers and the structure that would support them. On the other hand, the decentration distance must not exceed the amount beyond which the coma that results from decentration would become unacceptably large. In the case of an effective aperture of f/3, the coma would be only slightly in excess of the spherical aberration if the decentration were limited to about f/6. This would be enough to accommodate the fibers and supporting structure.

This work was done by Arthur H. Vaughan of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 92 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-18146.

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Correlation of N_2O and O_3 in the Atmosphere

Both positive and negative correlations are observed.

A report describes a study of the correlation between the concentrations of nitrous oxide and ozone in the atmosphere of the Antarctic region during the late austral winter. Because they are produced and destroyed outside the chemically perturbed lower stratosphere, N_2O and O_3 can serve as conservative tracers there. The strong anticorrelation between them provides a signature of the air in the lower stratosphere, and the alteration of the correlation at specific sites may indicate the loss of ozone or the mixing of perturbed and unperturbed air.

Concentrations of N_2O were measured by a laser absorption spectrometer aboard an ER-2 aircraft during five ferry flights between Ames Research Center (37° north latitude) and Punta Arenas, Chile (53° south latitude) and during 12 flights from Punta Arenas over Antarctica (between 53° and 72° south latitude). Mixing ratios of ozone were measured simultaneously by two instruments aboard the aircraft.

Only one of the ferry-flight paths involved an explicit attempt to measure vertical distributions of concentrations. In general, altitudes varied between 18 and 20 km and covered a sufficient range of latitudes to determine the effects of the slight dependence of the mixing ratios of N_2O and O_3 on latitude. As expected, the mixing ratio of N_2O was found to decrease poleward, while that of O_3 was found to increase poleward; that is, the correlation with respect to latitude was negative.

During the flights over Antarctica, data were taken at altitudes from 13.7 to 21 km. Because of the data storage limitations of the laser spectrometer and because of the required flightpath, a limited set of data exists for correlations between the mixing ratios of N_2O and O_3 outside the south polar vortex south of 55° south latitude.

Analysis of the data showed that the coefficient of correlation was always positive at the edge of the polar vortex (as that edge is defined by the maximum windspeed). Inside the vortex, in regions of lower windspeed, the correlation is negative, but the low mixing ratios of ozone observed there differentiate this air from lower stratospheric air outside the vortex. With few exceptions, regions of positive and negative correlation in the vortex were found to correspond to regions in which the mixing ratios of water were greater and lesser, respectively, than 2.9 parts per million by volume. The authors conclude that regions of positive correlation could be interpreted as evidence of either chemical depletion of ozone or horizontal mixing of normal air from the lower stratosphere with ozone-depleted air from the vortex.

This work was done by S. E. Strahan, M. Loewenstein, J. Podolske, W. L. Starr, and K. R. Chan of **Ames Research Center** *and M. H. Proffitt and K. K. Kelly of the NOAA/ERL Aeronomy Laboratory. To obtain a copy of the report, "Correlation of N_2O and Ozone in the Southern Polar Vortex During the Airborne Antarctic Ozone Experiment," Circle 24 on the TSP Request Card.*

ARC-12222

Near-Nadir Radar Backscatter From Ocean Waves

Some previous assumptions are questioned.

A paper discusses aspects of the theory of near-nadir radar backscatter from a well-developed sea. ("Well developed" is a relative term: the degree of development can be quantified as the ratio of the potential-energy density of the waves to the kinetic-energy density of the wind and is a function of the duration and fetch of the wind.) This study recently contributed to a development of a new technique for the determination of a sea-state bias in satellite altimeter measurements (the difference between the apparent sea level sensed by the altimeter and the true sea level) — as described by R. E. Glazman and M. A. Srokosz in "Equilibrium Wave Spectrum and Sea-State Bias in Satellite Altimetry", a manuscript submitted to the *Journal of Physical Oceanography*. The theory found a strong experimental confirmation in the work by Lee-Lueng Fu and R. Glazman, "The Effect of the Degree of Wave Development on the Sea-State Bias in Radar Altimeter Measurement", in press in the *Journal of Geophysical Research, Oceans*, as well as in other recent studies. This research also contributes to increased accuracy in the interpretation of remote-sensing measurements and to an expanded range of applications of satellite remote-sensing techniques for predicting weather, analyzing climate, and monitoring sea-lanes for safety.

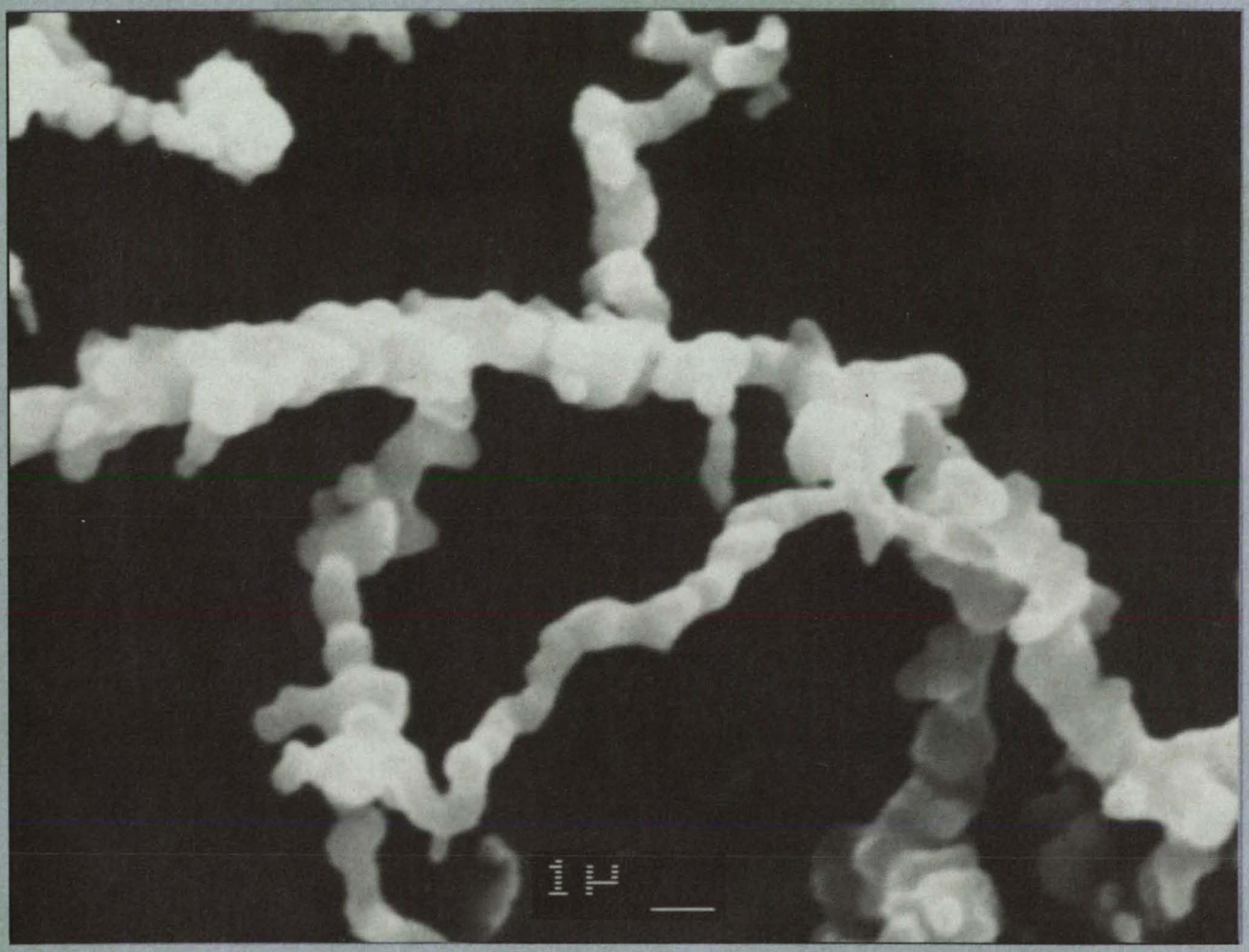
The paper introduces some previously developed equations for the radar-backscattering cross section, along with some critical assumptions that were made in deriving the equations. The first of these assumptions is that the surface is smooth on length scales comparable with the radar wavelength. One of the consequences of this assumption is that the backscattering at nadir and near-nadir incidence is computed to be inversely proportional to the root-mean-square slope of the surface. By a second assumption, the root-mean-square slope is a strong function of the speed of the wind. Consequently, the radar cross section at and near nadir incidence has commonly been presumed to be indicative of the local speed of the wind.

This paper questions both assumptions, bringing the currently accepted interpretation of nadir and near-nadir radar backscattering into doubt. In the first place, the assumption of smoothness on the radar-wavelength scale is not necessarily correct for a well developed sea. In the second place, the root-mean-square slope of the surface of a well developed sea makes little sense because it is a strong function of the length scale used in averaging and is, therefore, distorted by the previous assumption regarding smoothness. Therefore, in the absence of further information, the dependence of the radar cross section on the wind may be ambiguous.

In an effort to resolve the ambiguity, this paper indicates the need to (1) abandon the root-mean-square slope in favor of a correlation function calculated with the help of a weighted ocean-wave spectral function and (2) replace the previous averaging length scale (which was specified based solely on the radar wavelength) with an intrinsic surface microscale (an analogue of the Kolmogorov inner scale in turbulence), which marks the actual transition range in the wave-number spectrum of developed seas. The exact form of the weighting functions is not critical as long as it preserves the dominant contribution of high wave numbers in the ocean-wave spectrum. This requires consideration of the fractal regime of the surface-structure function at short ranges comparable to the averaging length scale. It is found that at exact nadir incidence, the radar cross section in the fractal regime is dominated by a component that represents the contribu-

NEW FROM INCO SPP...

EXTRA FINE NICKEL POWDER



Inco Type 210 Nickel Powder

JUST ADD YOUR IMAGINATION

SEND FOR YOUR FREE SAMPLE TODAY

INCO SPP

Park 80 West-Plaza Two, Saddle Brook, NJ 07662
Shin-Muromachi Building, 4-3 Nihonbashi-Muromachi 2-Chome, Chuo-ku, Tokyo 103 Japan
1-3 Grosvenor Place, London SW1X7EA England
15/Fl Wilson House, 19-27 Wyndham Street Central, Hong Kong

For More Information Circle No. 652

tion of numerous wavelets that appear on the surface because of its cascade geometry and, consequently, depends strongly on nonlocal aspects of the interactions between wind and waves.

This work was done by Roman E. Glazman of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Near-nadir radar back scatter from a well developed sea," Circle 43 on the TSP Request Card.*
NPO-17646

Condensation of Volatile Contaminant in an Instrument

Deposition of ice and other materials is investigated.

A report describes an investigation of the deposition of a contaminant of cooled optical detectors in the Wide-Field/Planetary Camera (WF/PC), an instrument that is part of the Hubble Space Telescope. During thermal vacuum tests, a contaminant, thought to be ice, was observed on cooled detectors in the WF/PC. This contaminant was easily removed when the detectors were warmed up while under vacuum and did not reappear when the detectors were cooled and used for imaging.

To better understand this phenomenon, initially thought to be the result of deposition of water from the graphite/epoxy optical-bench material in the instrument, the researchers mounted several diagnostic instruments on an access plate to monitor the interior of the WF/PC housing and the optical bench. So that this diagnostic instrumentation could not introduce additional contaminants, it was subjected to rigorous preconditioning, and only low-outgassing materials were used on the access plate.

The access plate was made of Vespel (SP-1) polyimide because this provided good thermal isolation from the WF/PC housing and the vacuum chamber, was easily machined, and was a low-outgassing material. A temperature-controlled quartz-crystal microbalance (TQCM) performed in-situ measurements of adsorbed and desorbed volatile condensible material on surfaces in the WF/PC, primarily those of the graphite/epoxy optical bench and electronics. The TQCM was instrumented with 15-MHz optically polished crystals, which were coated with aluminum to be representative of a reflective optical surface. The heat generated by the TQCM electronics was removed by a gold-plated copper heat sink, which was thermally coupled to a heat exchanger maintained at 10 ± 5 °C; this increased the accuracy of the TQCM measurements and enabled the monitoring of the contamination loading from the WF/PC optical bench and housing without changing the existing heat-flow paths. The vapor pressure was measured by a heat-loss gauge calibrated to extend the nominal useful lower range to 2×10^{-4} torr (3×10^{-2} Pa). An optical witness sample was an optically polished aluminum sample coated with MgF_2 to simulate an optical surface.

The thermal vacuum test of the WF/PC simulated three operating conditions that could be encountered in flight: nominal, hot, and cold. During these tests, the temperature of the TQCM was varied to measure the relative volatility of the surface contamination from the optical bench and housing. The optical witness sample followed the temperature of the housing and optical bench, to which it was thermally coupled by radiation. The temperature of the sample varied from approximately 35 °C to −5 °C.

As a result of these measurements, it was concluded that the TQCM collected an organic contaminant, not ice, when cold. Additional measurements indicated that the contamination was strongly correlated with the operation of the electronic equipment. The measurements of the reflectance of the optical witness sample indicated that when this sample was warmed to room temperature and atmospheric pressure, the contaminant did not cause a loss in reflectance.

Although the TQCM was not cold

enough to simulate the effect of the cooled detectors, the ice-free operation of the cooled detectors was verified with flat-field imaging.

This work was done by Patricia A. Hansen, Teresa K. Jenkins, Carl R. Maag, and Daniel M. Taylor of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report "Characterization of a Graphite Epoxy Optical Bench During Thermal Vacuum Cycling," Circle 44 on the TSP Request Card.*
NPO-18017

Parametric Instabilities of Alfvén Waves

A theoretical study focuses on instabilities in an anisotropic plasma.

A report presents a theoretical study of parametric instabilities of finite-amplitude, circularly-polarized Alfvén waves in a plasma that has pressure anisotropy. (Alfvén waves are hydromagnetic shear waves that move along magnetic-field lines.) Waves of the type studied are commonly observed in the solar wind and are conjectured to exist in interstellar and other cosmic plasmas.

The low-frequency behavior of a plasma is represented in this study by the Chew, Goldberger, and Low (CGL) equations, which are differential equations of magnetohydrodynamics in which the components of pressure parallel and perpendicular to the magnetic field are determined by two adiabatic equations of state. The Alfvén waves of the type studied are exact equilibrium solutions to the nonlinear CGL equations and of the Vlasov–Maxwell equations (which are differential equations for the propagation of electromagnetic waves in a hot, collisionless plasma).

A traditional linear-perturbation analysis is performed. To investigate the behavior of a wave in the presence of small fluctuations about its equilibrium state, a small perturbing wave is superimposed on the equilibrium wave. The evolution of the resulting total wave is calculated via the CGL equations, leading to a fifth-order equation that describes the relationship between the wave number (k) and the complex frequency (ω) of the total perturbed wave on the one hand and the wave number (k_0) and frequency (ω_0) of the pump wave (the original equilibrium, unperturbed wave) on the other hand.

A numerical solution of the dispersion equation reveals three different instabilities in wave-number space. The first is the modulational instability, which occurs at $k \leq k_0$. The second is the decay instability, which occurs at $k \geq k_0$ and has been discussed extensively by many authors.

The third instability occurs at $k > 2k_0$ and is called the "highly oscillating" instability.

The modulational instability is much weaker in comparison with the other two and has a very narrow bandwidth. The highly oscillating instability is a very broadband instability and grows the fastest. Both the modulational and highly oscillating instabilities exist only in the limited ranges of the magnetic-field, pressure, and density parameters in the dispersion equation.

The results show that in the modulational instability, the energy of the pump wave goes primarily to forward-propagating soundlike and Alfvén-like waves. In the decay instability, it goes to a forward-propagating soundlike wave. In the highly oscillating instability, it goes to a backward-propagating soundlike wave.

This work was done by Hiromitsu Hamabata of **Ames Research Center**. *To obtain a copy of the report, "Parametric Instabilities of Finite-Amplitude, Circularly Polarized Alfvén Waves in an Anisotropic Plasma," Circle 6 on the TSP Request Card.*
ARC-12325

Frequency Responses of Hot-Wire Anemometers

Effects of various circuit parameters are discussed.

A report describes a theoretical study of the frequency response of a constant-temperature hot-wire anemometer, with a view toward increasing its frequency response while maintaining stable operation in supersonic flow. In such an anemometer, the hot wire, which is cooled by the flow to be measured, is one arm of a bridge circuit. An amplifier senses the unbalance in the bridge circuit and attempts to reduce the unbalance by adjusting the current supplied to the bridge. In effect, the overall circuit strives to follow the fluctuations in the flow by supplying the hot wire with the fluctuating electric current that keeps its resistance and, thereby, its temperature constant. The output voltage of the amplifier is recorded as the signal indicative of the flow. The frequency response of this voltage with respect to fluctuations in the speed of flow is the concern of this study.

The report contains five sections. The first two explain, in general terms, how the parameters of the bridge and amplifier circuits and the characteristic thermal-response time of the hot wire affect the frequency response of the overall circuit. Supersonic flow enters the problem only by increasing the cooling rate, reducing the thermal-response time of the wire. To represent this frequency response, the third section of the report presents a seventh-order-polynomial Laplace transform that was introduced in a previous study. Two capacitances — one associated with the hot wire, the other with the balance resistor — are set to zero, reducing the model to fifth order.

The remaining sections of the report discuss the influence of the gain, offset voltage, and frequency response of the amplifier, and of the interaction between the amplifier and the inductances in the bridge circuit. The fourth section focuses on the offset voltage, and particularly on the response of the overall circuit to a square-wave fluctuation in offset voltage. This type of analysis is important because such square-wave tests are invaluable in the adjustment of hot-wire anemometer circuits. The response to a square wave approximates the response to a step-function change in the offset voltage, which, in turn, approximates the response to a delta-function fluctuation in velocity. However, some of the rules that are currently being used to deduce frequency responses from square-wave tests are misleading because they are based on oversimplified mathematical models. The more complicated mathematical model used here reveals important relationships among (1) the damping of spurious oscillations in the responses to square-wave fluctuations in the offset voltage or in the flow, (2) the inductance in the cable leading to the hot wire, (3) the inductance in the balance arm of the bridge circuit, and (4) the steady component of offset voltage.

The fifth section focuses on the frequency response and gain of the amplifier. Intuitively, it might be expected that the rolloff frequency of the amplifier would play a dominant role in determining the overall frequency response of the system. However, it was shown in a previous study that the offset voltage and inductance of the cable leading to the hot wire are usually the most important variables that govern the overall response. Here, it is shown that while the frequency response of the overall system can be improved significantly by improving the frequency response of the amplifier, the role of the amplifier is often more critical in determining the stability of the system. The effect of the amplifier upon stability is revealed in this study via its effect on the higher-order poles of the transfer function of the system.

This work was done by Jonathan H. Watmuff of Princeton University for **Ames Research Center**. *To obtain a copy of the report, "Increasing the Frequency Response of Constant Temperature Hot-Wire Systems for Use in Supersonic Flow," Circle 67 on the TSP Request Card.*
ARC-12469

Burning of Dense Clusters of Fuel Drops

A theoretical model of evaporation, ignition, and combustion is presented.

A report presents a theoretical study of the evaporation, ignition, and combustion of rich and relatively dense clusters of drops of liquid fuel. This is yet another in a continuing series of studies of the combustion of sprayed liquid fuels. In this case, the focus is on the interactions between the heterogenous liquid/gas mixture in a cluster and the flame that surrounds it (experiments have shown that the flame is a thin sheet).

The interactions involve, among other things, the evaporation of the fuel within the cluster and the transport of the vapor outside the cluster to the flame. Although it would be desirable to analyze these interactions for the whole spray, such an analysis would be excessively complicated. To reduce the complexity to a manageable level, this study focuses on only one of many clusters in a spray, and the mathematical model of the interactions is constructed with some simplifying assumptions.

In the model, the drops are all of the same size, spherical, and uniformly distributed in the cluster, which is also spherical. The cluster moves in the ambient gas. On a length scale equivalent to many drop radii, the cluster is spatially homogeneous in thermodynamic quantities. Initially, the gas inside the cluster is quiescent, but as the drops move through the ambient gas, the gas inside the cluster acquires a velocity relative to the to fixed system of coordinates. The ambient temperature is much greater than is the initial temperature of the drops, and so the drops heat up and evaporate. Since the ambient gas consists of air with traces of fuel vapor, eventually ignition occurs and combustion ensues.

The pressure in the cluster remains atmospheric. Each drop moves radially with respect to the center of the cluster in a self-similar manner with respect to the other drops, and the outer boundary remains spherical. The forces on the drops are attributed to evaporation, drag on the drops, and drag on the cluster as a whole. In general, the equations for the conservation of momentum are consistent with the assumption of self-similarity, with the exception of the nonlinear drag and convective-derivative terms. To obtain a formulation consistent with the assumption of spatial homogeneity in the thermodynamic quantities, equations in terms of averages over the whole cluster are formed by integrating over the self-similarity relative-radial-position parameter. During this process, some convective coupling between axial and radial velocities is eliminated, and the tendency of the nonlinear drag to destroy the self-similar radial motion is also neglected.

Calculations are performed for n-decane fuel at various initial air-to-fuel mass ratios. The results show that in a moderately dense spray, cluster burning lasts only a limited time. For the range of parameters used in this study, only 40 percent or less of the fuel has been burned at the moment when the drops disappear. Then a gas-phase-only burning mode takes over. This second mode completely dominates the burning of a very dense cluster in which ignition occurs after the drops have evaporated. These findings are in qualitative agreement with existing experimental observations. During cluster burning, a sheet of flame is established extremely close to the surface of the cluster, in agreement with existing experimental observations.

The ignition event features the propagation of a premixed flame through the cluster. The consequent heating of the cluster causes it to expand to about 150 percent of its previous radius. The fraction of fuel burned and the sudden increase in temperature at ignition depend mainly on the air/fuel mass ratio.

This work was done by Josette Bellan

and Kenneth G. Harstad of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Evaporation, Ignition and Combustion of Non Dilute Clusters of Drops," Circle 158 on the TSP Request Card. NPO-17987*

Ultraviolet Spectrum and Chemical Reactivity of ClO Dimer

This dimer is important in photochemistry of the Antarctic stratosphere.

A report describes an experimental study of the ultraviolet spectrum and chemical reactivity of the dimer of chlorine monoxide (ClO). On the basis of prior studies, this dimer is known to be important in the photochemistry of the Antarctic stratosphere. The objectives of this study were to (1) measure the absorption cross sections of the dimer at near-ultraviolet wavelengths, (2) determine whether the asymmetrical isomer (ClOClO) of the dimer can exist at temperatures relevant to the Antarctic stratosphere, and (3) test for certain chemical reactions of the dimer, especially those relevant to the Antarctic "ozone hole."

The experiments were conducted at temperatures from 195 to 217 K, both in the gas phase and in such cryogenic solvents as CF_4, CO_2, and N_2O. A few experiments in the gas phase were also carried out at room temperature, primarily for comparison of quantum yields of ozone in the two temperature ranges. The solvent experiments were chosen to provide optimum conditions for stabilization of possible metastable isomers of the dimer; namely, a low temperature and a high effective concentration of third-body (M) molecules in the $ClO+ClO+M$ reaction. The dimer was prepared, in some cases, by photolysis of Cl_2/O_3 or Cl_2/Cl_2O mixtures, and in other cases by photolysis of Cl_2O alone. The source of light for photolysis was a mercury lamp with a cutoff filter to eliminate radiation at wavelengths less than 300 nm.

Absorption cross sections of the dimer in the gas phase and in the solvents were measured at wavelengths from 190 to 400 nm. The gas-phase and solvent spectra were nearly identical, with little, if any, solvent shift in the wavelength of the spectral peak.

If the asymmetrical isomer ClOClO were present, it would be expected to yield OClO upon reaction with atomic chlorine. OClO is readily detectable via its strong characteristic ultraviolet absorption spectrum. OClO would also be expected to give rise to Cl_2O_3, which also has a strong absorption spectrum. However, the characteristic spectra of OClO and Cl_2O_3 were not observed, leading to the conclusion that the asymmetrical isomer ClOClO cannot be stabilized at temperatures of 195 K and above and therefore cannot play a significant role in the Antarctic stratosphere. Thus, it is concluded further that the symmetrical isomer ClOOCl is the only stable one.

Of the chemical reactions studied, the one of primary interest was the postulated reaction $ClOOCl+O_3 \rightarrow ClO+ClOO+O_2$. However, evidence of this reaction was not observed, and on the basis of prior experiments, it was concluded that the rate constant of this reaction does not exceed 1×10^{-19} cm^3s^{-1}. For the self-reaction $ClOOCl+ClOOCl \rightarrow 2Cl_2+O_2$, the upper limit of the rate constant was found to be 1×10^{-20} $cm^{-3}\,s^{-1}$.

This work was done by William B. DeMore of Caltech and E. Tschuikow-Roux of the University of Calgary for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "UV Spectrum and Chemical Reactivity of the ClO Dimer," Circle 137 on the TSP Request Card.*
NPO-18143

High-Quality TiS_2 for Li/TiS_2 Cells

A modified process includes an all-vapor-phase reaction between sulfur and titanium.

NASA's Jet Propulsion Laboratory, Pasadena, California

A modified process for the synthesis of battery-grade titanium sulfide (TiS_2) yields substantially improved material for Li/TiS_2 electrochemical cells. The TiS_2 product is less dense and more homogeneous, consists of smaller particles of higher crystalline quality, and is purer. A purification step to remove unreacted sulfur, S, TiS, and TiS_3 from the TiS_2 product may no longer be necessary.

Cells made with the improved material have a high cathode utilization and long cycle life performance. They are expected to find applications in rechargeable lithium batteries for spacecraft, military equipment, telecommunication systems, automobiles, and consumer products.

The modified process is based on a vapor-transport method in which a titanium sponge is exposed to sulfur vapor in a reaction vessel. The main modifications to the basic method are as follows:

- Granular sulfur is used instead of the usual fine-powder sulfur.
- The solid raw materials — sulfur and titanium — are kept separate at the beginning of the reaction by placing them at opposite ends of the reaction vessel.
- The reaction vessel is tilted in the furnace.
- The temperature profile in the vessel is optimized and controlled precisely.

The granular sulfur can be weighed out more accurately and is less vulnerable to contamination. Keeping the raw materials separate prevents molten sulfur from reacting with the titanium; only sulfur vapor is transported to the titanium sponge. In comparison with sulfur liquid, sulfur, vapor produces a lower-density, high-surface-area, smaller-particle electrode material without unreacted or partially reacted sulfur inclusions. The reaction vessel is tilted for the same reason: condensed sulfur liquid drains off, leaving only sulfur vapor to react with the titanium.

The optimized and precisely controlled temperature profile ensures that the reaction proceeds quickly and completely. From experiments, it appears that a temperature of 360 – 400 °C at the sulfur end of the reactor and 450 – 500 °C at the titanium end yields the purest, highest-quality product.

This work was done by Chen-Kuo Huang, Subbarao Surampudi, David H. Shen, Fotios Delgiannis, and Gerald Halpert of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 91 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
Director of Patents and Licensing
Mail Stop 305-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125

Refer to NPO-17883, volume and number of this NASA Tech Briefs *issue, and the page number.*

Computer Programs

COSMIC: Transferring NASA Software

COSMIC, NASA's Computer Software Management and Information Center, distributes software developed with NASA funding to industry, other government agencies and academia.

COSMIC's inventory is updated regularly; new programs are reported in *Tech Briefs*. For additional information on any of the programs described here, circle the appropriate TSP number.

If you don't find a program in this issue that meets your needs, call COSMIC directly for a free review of programs in your area of interest. You can also purchase the annual *COSMIC Software Catalog*, containing descriptions and ordering information for available software.

COSMIC is part of NASA's Technology Utilization Network.

COSMIC® *John A. Gibson, Director,*
Phone (404) 542-3265 ; FAX (404) 542-4807
The University of Georgia, 382 East Broad Street, Athens, Georgia 30602

Computer Programs

These programs may be obtained at a very reasonable cost from COSMIC, a facility sponsored by NASA to make computer programs available to the public. For information on program price, size, and availability, circle the reference number on the TSP and COSMIC Request Card in this issue.

Mathematics and Information Sciences

Program Enhances Drawings of Three-Dimensional Objects

Subsets of polygons can be rendered as silhouettes.

Flexibility in choosing how to display computer-generated drawings of three-dimensional objects has become increasingly important in recent years. A major consideration is the enhancement of the realism and aesthetics of the presentation. A polygonal representation of objects, even with hidden lines removed, is not always desirable. A more pleasing pictorial representation often can be achieved by removing some of the remaining visible lines, thus creating silhouettes (or outlines) of selected surfaces of an object.

SILHOUETTE is a program for line drawings that can render any subset of polygons as a silhouette. The SILHOUETTE program is an improvement on, and a replacement for, HIDDEN LINE COMPUTER CODE (ARC-11446). The program is flexible enough to be applicable to every class of object. SILHOUETTE offers all possible combinations of silhouette and nonsilhouette specifications for an arbitrary solid. Thus, it is possible to enhance the clarity of any three-dimensional scene presented in two dimensions. Inputs to the program can be polygons or segments of lines. Polygons designated with the same number will be drawn as a silhouette of those polygons.

SILHOUETTE is written in FORTRAN 77 and requires a graphics package like DI-3000. The program has been implemented on a DEC VAX-series computer operating under VMS and uses 65K of virtual memory without a graphics routine linked in. SILHOUETTE was developed in 1986 and released by COSMIC in 1990.

DEC, VAX, and VMS are trademarks of Digital Equipment Corp. DI-3000 is a trademark of Precision Visuals.

This program was written by David R. Hedgley, Jr., of **Ames Research Center**. *For further information, Circle 122 on the TSP Request Card.*
ARC-12721

Computer-Assisted Scheduling System (COMPASS)

Activities and resources can be scheduled manually, semiautomatically, or automatically.

COMPASS is an interactive planning and scheduling software system with a mouse-driven X-Windows user interface. COMPASS is used much like a spreadsheet to create and revise schedules of activities. In a typical scenario, the user loads data on activities and resources from a data file, creates a schedule by invoking a series of high-level scheduling and editing commands, and saves the resulting schedule in a data file, from which it can be retrieved for later publication or revision.

COMPASS enables the user to control the sequence of the scheduling process and the general placement of activities on the timeline. At the same time, the user can rely upon the system to place activities only at feasible times, taking into consideration all of the constraints imposed upon an activity and the resources that it requires. The user can schedule activities one at a time to control the resulting product carefully, or the user can command the computer to schedule everything automatically, without human intervention.

COMPASS is suitable for a wide range of problems, including the scheduling of both activities and projects. It has the capabilities necessary for the creation and revision of plans in advance of execution times and for revision of plans at execution times in response to failures and delays. It can be used to manage activities that are subject to constraints of timing, of ordering, and of the availability of resources. It can be used to manage a wide range of resources, including tools, equipment, crews, electricity, and water. The resources can be used and then returned by an activity (e.g., tools), consumed by an activity (e.g., propellant), or even produced or resupplied by an activity (e.g., water).

COMPASS version 1.4 is written in Ada and contains standard X-Windows interfaces written in C; the program is easily ported between machines that support these standards. Currently, COMPASS runs on Sun Workstations with SunOS 3.5 or 4.0, X-Windows release 11.3 or later, and the Verdix Ada compiler. Memory requirements are 4 MB main memory and 2 MB free disk space. There are binaries for both SUN-3 and SPARC workstations, including three executable versions of the program for each: one that uses an ASCII interface, one that uses a monochrome X-Windows interface, and one that uses a color X-Windows interface. The application program, the Ada program library, and the X-Windows interface can easily be customized for other specific scheduling applications. COMPASS was developed in 1989.

SunOS, SUN-3, and SPARC are trademarks of Sun Microsystems, Inc. Sun Workstation is a registered trademark of Sun Microsystems, Inc. X-Window System is a trademark of the Massachusetts Institute of Technology. Verdix is a trademark of Verdix Corp.

This program was written by Barry R. Fox of McDonnell Douglas Space Systems Co. for **Johnson Space Center**. *For further information, Circle 70 on the TSP Request Card.*
MSC-21772

Program for Graphical Presentation of Schedules

Editing can be done quickly and easily on the screen.

OPPS is a window-based graphics software tool that provides easy and fast on-screen "what-you-see-is-what-you-get" (WYSIWYG) editing capabilities. It provides a canvas area that displays a full image of the schedule being edited. The canvas contains a header area (for text) and a schedule area (for plotting graphical representations of "milestone" objects in a flexible time line).

The OPPS software is object-oriented, but it is unique in its capability for creating objects that have date attributes. Each object on the screen can be treated as a unit for moving, editing, and the like. There is a mouse interface for simple control of the location of a pointer. The user can position objects to resolution as fine as one picture element, but objects with which dates are associated are positioned automatically in their correct time-line positions in the schedule area.

The schedule area, regarded as a page, contains horizontal lines across the page, and there are capabilities for multiple pages and for editing the number of lines per page and the line grid. The text on a line can be edited, and a line can be moved, all objects on the line moving with it. The time-line display can be edited to plot any period in a variety of formats from fiscal year to calendar year and from days to years. Text objects and image objects (raster files and icons) can be created for placement anywhere on the page.

"Milestone"-event objects (with each of which is associated a single date, optional text, and optional milestone symbol) and activity objects (with each of which is associated a starting date, an ending date, and an optional date of completion) include unique editing panels for entering data. A representation for schedule slips is also

provided. A milestone schedule can be saved in an ASCII file on another computer to be read by OPPS. The program can also print a schedule to a PostScript file.

This program is not intended to replace a commercial scheduling and/or project-management program. It does not provide the capability for defining dependencies between activities; dates must be provided manually. However, because OPPS includes an ASCII file interface, it can be used in conjunction with project-management software to produce schedules that have appearances indicative of quality.

OPPS is written in C language and runs under Sunview on a Sun workstation with SunOS 4.0 or higher. The required memory is 340K main memory plus 1.5 MB free disk space. A binary is included for SUN-4 computers. OPPS was developed in 1990.

SunOS, Sunview, and SUN4 are trademarks of Sun Microsystems, Inc. Sun workstation is a registered trademark of Sun Microsystems, Inc. PostScript is a trademark of Adobe Systems, Inc.

This program was written by Susan C. Murphy and Ana Maria Guerrero of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 114 on the TSP Request Card.*
NPO-18439

Menu-Driven Program Displays Data in Real Time

The operator can monitor the progress of an experiment more effectively.

Experiments that involve the Olympus spacecraft have led to the development of JPL/VIEW, a menu-driven computer program that retrieves and displays incoming propagation data as they reach the hard disk of the associated data-acquisition-and-storage system. The display of data in real time while they are being collected and stored increases the effectiveness of any data-recording system. Real-time display enables the operator to monitor the progress of events and respond swiftly to errors during an experiment or trial operation.

JPL/VIEW displays the powers of the signals received from 12.5-, 20-, and 30-GHz beacons of the Olympus spacecraft, as well as the sky temperatures at those frequencies. A "system-status" window presents the temperature of the system, the ambient temperature, the rain rate, direction and speed of the wind, and the states of various components.

The program comprises three multitasking processes and additional support routines: (1) GRAPH_WINDOW, which governs the user interface; (2) FILE_GRAPH, which maintains the plotting area when the user is viewing a file; and (3) REAL_TIME, which maintains the incoming data, the status of the collection system generating the real-time plots, and the "system-status" window. A non-preemptive multitasking operating software shell facilitates real-time monitoring of the incoming beacon data and the status of the data-collection system, eliminating procedure calls that take too much time by transferring control directly from one monitoring routine to another.

JPL/VIEW is written in Microsoft C, version 5.1, and includes several assembly-language subroutines compiled with Microsoft MASM (Macro ASseMbler).The program was designed for use on an 80286-based IBM PS/2 computer with a pointing device and a color EGA or VGA monitor. The optional use of a hard drive speeds execution of the program. The standard distribution medium for this package is two 1.2-MB 5.25-in. (13.34-cm) IBM PC-DOS format diskettes. JPL/VIEW was developed in 1990 and is a copyrighted work with all copyright vested in NASA.

This program was written by John C. McKeeman and William R. Sylvester, Jr., of Virginia Polytechnic Institute and State University for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 33 on the TSP Request Card.*
NPO-18365

Mechanics

Hardware, Techniques, and Processes

Books and Reports

Automated Characterization of Vibrations of a Structure

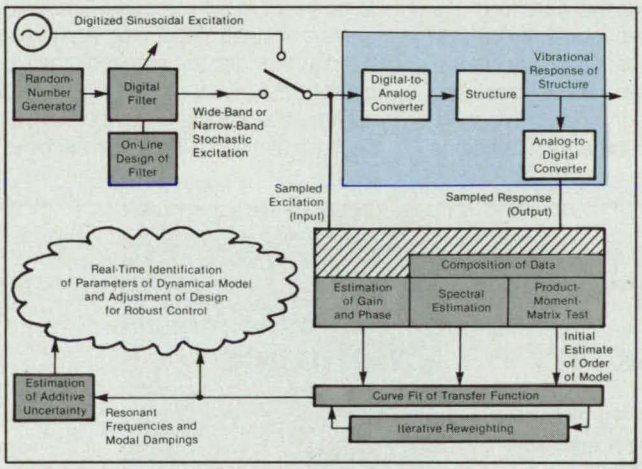
Excitations, measurements, and computations yield data for design of robust stabilizing control systems.

NASA's Jet Propulsion Laboratory, Pasadena, California

An automated method of characterizing the dynamical properties of a large flexible structure yields estimates of modal parameters that can be used by a robust control system to stabilize the structure and minimize undesired motions. Although it was developed for the control of large, flexible structures in outer space, the method is also applicable to terrestrial structures in which vibrations are important — especially aircraft, buildings, bridges, cranes, and drill strings.

The method was developed for use in the presence of the following practical constraints encountered in the large-flexible-structure problem: (1) The structure cannot be characterized in advance with enough accuracy for purposes of control. (2) The dynamics of the structure can change in service. (3) The numbers, types, placements, and frequency responses of sensors that measure the motions and actuators that control them are limited. (4) The time available during service for characterization of the dynamics is limited. (5) The dynamics are dominated by resonant modes of low frequency. (6) In-service measurements of the dynamics are supervised by a digital computer and are taken at low rates of sampling, consistent with the low characteristic frequencies of the control system. (7) The system must operate under little or no human supervision.

The method is based on the extraction of the desired modal and control-design data from the responses of the structure to known vibrational excitations (see figure). Initially, wideband stochastic excitations are used to obtain a survey of the general characteristics of the structure. Next, narrow-band stochastic and piecewise-constant (consistent with sample-and-hold discretizations) approximations to sinusoidal excitations are used to investigate specific frequency bands in more detail.



The **Method for the Automated Characterization of Vibrations** of a structure prescribes equipment, theory, and procedures for applying known vibrational excitations, measuring the vibrational responses, and processing the data on the excitations and responses into the desired model and control-design data.

The relationships between the responses and the excitations are first computed nonparametrically — by spectral estimation in the case of stochastic excitations and by estimation of gains and phases in the case of the approximately sinusoidal excitations. In anticipation of the parametric curve fitting to follow, the order of a mathematical model of the dynamics of the structure is estimated by use of a product-moment-matrix (PMM) test. Next, the parameters of this model are identified by a least-squares fit of transfer-function coefficients to the nonparametric data. The fit is performed by an iterative reweighting technique to remove high-frequency emphasis and assure minimum-variance estimation of the transfer-function coefficients. The order of the model starts at the PMM estimate and is determined more precisely thereafter by successively adjusting the number of modes in the fit at each iteration until an adequately small output-error profile is observed.

In the analysis of the output error, the additive uncertainty is estimated to characterize the quality of the parametric estimate of the transfer function and for later use in the analysis and design of robust control. It can be shown that if the additive uncertainty is smaller than a certain calculable quantity, then a conceptual control system that could stabilize the model structure could also stabilize the real structure. This criterion can be incorporated into an iterative design procedure. In this procedure, each controller in a sequence of controllers for the model structure would be designed to perform better than the previous one did, until the condition for robust stability was violated. Once the violation occurred, one could accept the penultimate design (if its performance were satisfactory) or continue the design process by increasing a robustness weighting (if available). In principle, convergence of this iterative process guarantees a control design that provides high performance for the model structure while guaranteeing robustness of stability to all perturbations of the structure within the additive uncertainty.

This work was done by David S. Bayard, Yeung Yam, Edward Mettler, Fred Y. Hadaegh, Mark H. Milman, and Robert E. Scheid of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 99 on the TSP Request Card.*
NPO-18141

External Squeeze-Film Damper for Hydrostatic Bearing

Stacked disks provide both damping and clearance for alignment.

Marshall Space Flight Center, Alabama

An external squeeze-film damping device helps to suppress the vibrations of a rapidly turning shaft supported by a pivoted-pad hydrostatic bearing in a high-pressure/high-power-density turbomachine. The hydrostatic bearings in such a machine are intended to overcome the limitations of conventional rolling-element bearings. To be effective, a hydrostatic bearing must operate at small clearances. A pivoted-pad bearing provides the required small clearances, yet adjusts and aligns itself to accommodate the significant structural deflections that occur in such a machine. The external squeeze-film damping device is incorporated into the pivoted-pad bearing.

The basic pivoted-pad bearing without the damper includes bearing pads arranged around the shaft. Each pad includes holes through which fluid is pumped to the working surface of the pad. Each pad is preloaded against the shaft by a piston that has a convex crown and that is pressurized by the pumped fluid.

The damping device is incorporated by placing it between the convex crown of the piston and the top of the piston cylinder. The damper consists of a stack of washer-like disks. The damping squeeze-film force between any two given disks is inversely proportional to the gap between the disks and increases with the velocity of approach of the disks and with the viscosity of the fluid in the gaps. The gaps in the stack are narrow enough to provide high damping force, while the total of the gaps amounts to sufficient clearance for self-alignment of the bearing.

This work was done by Paul S. Buckmann of GenCorp Aerojet for **Marshall Space Flight Center**. *No further documentation is available.*

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457(f)], to GenCorp Aerojet. Inquiries concerning licenses for its commercial development should be addressed to

Carolyne S. Montgomery
Contract Manager
GenCorp Aerojet Propulsion Division
Bldg. 2019A/Dept. 9001
Sacramento, CA 95813

Refer to MFS-28555, volume and number of this NASA Tech Briefs *issue, and the page number.*

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Modeling for Stabilization of Segmented Telescope Reflector

The vibrating reflector structure is treated as a collection of substructures, each initially treated separately.

A report discusses the mathematical modeling of vibrations and of active control to suppress vibrations of a large, segmented telescope reflector. A reflector of this type is a large paraboloidal mirror composed of regular hexagonal (as viewed along the optical axis) mirror segments, each connected to a supporting structure by three actuators that adjust its position and orientation in response to commands from a control subsystem. Accelerometers collocated with the actuators measure the vibrations. Interferometric edge sensors measure the relative angles and displacements between adjacent panels. The problem is to devise control laws that process the outputs of the edge sensors and accelerometers into actuator commands to suppress vibrations and maintain the required figure of the mirror surface.The control laws are required to assure stability.

To circumvent the difficulty of treating a system characterized by many degrees of freedom, this study follows the decentralized-control approach, which is widely used in the control and analysis of such diverse systems as power networks, urban traffic networks, digital communication networks, ecological systems, economic systems, and robotic manipulators. In the decentralized-control approach, the overall system is first decomposed mathematically into subsystems. Control laws and criteria for stability are developed for each subsystem. Then the mathematical properties of the interconnections among the subsystems are used to assemble the subsystems mathematically into a model of the overall system and to derive global control laws and criteria for the stability of the overall system.

In this case, the subsystems are the panels and the beams that support them. The reflector panels are modeled as rigid bodies, the beams are treated as undergoing small deflections in the linear regime, and the actuators are modeled as rigid links in series with stiff springs. The panels are assumed not to undergo lateral motions. From this model, equations of motion of each subsystem are derived.

Control laws for each subsystem treated in isolation are derived by pole placement in the frequency domain, using feedback from the sensors pertinent to that subsystem alone. A criterion for the stability of the overall system is derived. Computer simulations are performed with these control laws, using parameters representative of a reflector composed of 18 panels, each 1 m in diameter; it is shown that vibrations would be suppressed considerably — typically by a factor of 1,000 in comparison with an open-loop vibration-attenuation mechanism.

This work was done by Che-Hang C. Ih of Caltech and Helen A. Boussalis of California State University for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Modeling and Stability of Segmented Reflector Telescopes," Circle 63 on the TSP Request Card.*
NPO-18109

Three-Component Laser Velocimetry of Complex Flows

Laser velocimetry is used to validate computed predictions of complex flow fields.

Classic aircraft design has been based on experimental results from wind-tunnel

models and free-flight testing of prototype aircraft. Recent advances in computational fluid dynamics are changing this approach. The aeronautical research community is beginning to depend more on computations than on experimental results to such an extent that predictions of flow-field behavior are being used without supporting data. The question arises as to whether predictions of complex flow fields represent the real world.

An experiment was performed in an attempt to use a wind tunnel and state-of-the-art instrumentation to look into the real world. The subject of this study was a common, yet complex flow: vortex rollup along and above the leading edge of a highly swept (75°) delta wing.

The Basic Aerodynamics Research Tunnel (BART) at NASA Langley Research Center was selected to approximate the real world. The input flow of this wind tunnel has very low turbulence and remains stable during the long times required to conduct detailed investigations. An orthogonal three-component laser velocimeter served as the primary measuring instrument. It was used to measure the leading-edge vortex flow field above the wing at angles of attack of 20.5° and 40.0°.

The analysis of uncertainties in the measurements showed mean velocity measurements to be accurate to within 0.5 percent and turbulence-intensity measurements to be accurate above twice the residual value of 1 percent. Mean-velocity and turbulence-intensity contours of the vortex flow field at an angle of attack of 20.5° were determined along with contours of burst vortexes when the angle of attack was raised to 40°. These results, along with the estimates of integral time scale, demonstrated the capabilities of the orthogonal three-component laser velocimeter to obtain the detailed experimental data necessary to validate the computational codes used.

This work was done by James F. Meyers of **Langley Research Center** *and Timothy E. Hepner of the United States Army (AVRADCOM). For further information, Circle 140 on the TSP Request Card.*
LAR-14387

Effects of Spatial Disturbances on Asymmetries of Vortexes

Small input asymmetries of surfaces or flows are amplified downstream.

A report describes a computational study of the effects of small spatial disturbances on the asymmetries in the vortexes downstream of slender bodies of revolution in flows at a large angle of attack. Flow phenomena of this type can affect the stability and other maneuvering characteristics of missiles and aircraft. For example, the onset of asymmetry in the vortexes on the forebody of a vehicle maneuvering at a large angle of attack can generate unwanted yawing moments, which can cause loss of control. Understanding of these phenomena can also help to answer such important design questions as how precisely symmetrical an aerodynamic body should be and how strongly roughness, bumps, or other imperfections on its surface affect its maneuvering characteristics.

Two axisymmetric bodies were used in this study. Both were missilelike ogive/cylinders, and one was augmented with an axisymmetric rearward-projecting sting (a rod used to mount a model in a wind tunnel) to provide a more realistic simulated flow for comparison with experiments. Subsonic viscous flows about these bodies were mathematically modeled via the Navier–Stokes equations, which were integrated numerically via an implicit finite-difference algorithm. All of the simulated flows were characterized by a free-stream Mach number of 0.2 and an angle of attack of 40°. The symmetry of the flow was broken by introducing a small, steady jet perpendicular to the plane of incidence. Four cases were studied: the symmetric flow (without the jet) and one asymmetric flow (with the jet) about the body without the sting, and two asymmetric flows (with the jets at different positions) about the body with the sting.

The computed flows exhibited marked asymmetries like those that had been observed previously in experiments. Analysis of the computed flows leads to the following generalizations:

1. In the absence of a steady, stationary symmetry-breaking perturbation, the computed flows around bodies of revolution at large angles of attack do not become asymmetric, in contrast to the asymmetries observed experimentally.
2. The computed symmetric flows are stable to perturbations that vary with time. Even after an asymmetric solution develops in response to a perturbation, removal of the perturbation causes the asymmetric flow to relax to the original symmetric state.
3. The degree of asymmetry in a computed solution is a function of the strength of the applied disturbance. A decrease in the strength of a stationary jet causes a corresponding decrease in the observed asymmetry.
4. The effectiveness of a perturbation of given strength is a strong function of its point of application. A perturbation applied close to the nose induces a much greater asymmetry than does the same perturbation applied farther downstream.

The results of this computational study parallel the findings of previous experimental studies and explain why asymmetry is almost always observed in the experiments. Despite all possible care taken in construct-

ing a model, small irregularities exist near the tip. Taken together, the computational and experimental observations suggest that the asymmetries of three-dimensional vortexes on slender bodies at large angles of attack are forced by stationary, steady disturbances like those caused by the roughnesses of the surfaces.

This work was done by David Degani and Lewis B. Schiff of **Ames Research Center**. *Further information may be found in AIAA paper 89A-25287, "Numerical Simulation of the Effect of Spatial Disturbances on Vortex Asymmetry."*

Copies may be purchased [prepayment required] from AIAA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500.

ARC-12440

Shedding of Vortices From a Missilelike Body

At large angles of attack, flows exhibit self-sustained oscillations.

A report describes a computational study of subsonic flows about slender bodies of revolution at large angles of attack. This is one in a continuing series of studies intended to elucidate the aerodynamics of missiles and aircraft undergoing severe maneuvers. In this case, the focus is upon the effect of the angle of attack on the development of unsteadiness in flow — particularly the unsteady shedding of vortices on the leeward side.

Flows about three similar missilelike axisymmetric ogive/cylinder bodies were computed by a thin-layer Navier–Stokes code. A half-body grid was used, constraining the simulated flows to be symmetrical. Although this feature prevents the simulation from showing the asymmetry that is observed experimentally at large angles of attack, it nevertheless permits the simulation to follow experimentally observed trends in the development of unsteady flow.

Flows were computed for a free-stream mach number of 0.2. Laminar cases were computed at Reynolds numbers (based on free-stream conditions and the diameter of the cylinder) of 75,000 and 200,000 for angles of attack from 10° to 40° in increments of 5°. Time-accurate computations of turbulent flows were performed for a Reynolds number of 5×10^6 at angles of attack of 20°, 25°, and 30°. The computations were started from undisturbed free-stream conditions or from solutions obtained previously at nearby Reynolds numbers or angles of attack, and the equations of flow were advanced in time to obtain histories of the flows.

In most cases investigated, the computed flows settled down to steady states. However, as the angle of attack was increased, the fluctuations in the flows became less damped. The unsteadiness was linked to small three-dimensional vortices moving along the primary surfaces of crossflow separation.

At an angle of attack of 10°, the primary crossflow separation started downstream of the ogive/cylinder junction, the primary crossflow vortices were small and lay close to the leeward surface, and no secondary separation was observed. With an increase in the angle of attack, the primary crossflow separation developed close to the nose, and the primary vortices became larger (and stronger) and lay farther above the body. As the strength of the primary vortices increased, the secondary crossflow separation and the associated development of secondary vortices also occurred closer to the nose. At an angle of attack of 40° the flow remained unsteady, with self-sustaining fluctuations. Although the computations cannot be compared directly with experiments because they involve different Reynolds numbers, it is noteworthy that experiments also indicate a trend toward increasing unsteadiness with increasing angle of attack.

This work was done by Lewis B. Schiff, David Degani, and Sharad Gavali of **Ames Research Center**. *Further information may be found in AIAA paper 89A-25170,*

"Numerical Simulation of Vortex Unsteadiness on Slender Bodies of Revolution at Large Incidence."

Copies may be purchased [prepayment required] from AIAA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500.

ARC-12441

Lightweight Shield Against Space Debris

Transportable, deployable panels would offer thermal insulation as well as protection against meteoroids.

A report presents a concept for a lightweight, deployable shield that would protect orbiting spacecraft against meteoroids and debris. The shield also would function as a barrier to conductive and radiative losses of heat.

The proposed shield would be made in four segments that, together, would provide 360° coverage of a cylindrical space-station module. A segment would include a network of longitudinal and circumferential structural elements laminated to thin aluminum strips. Panels that would absorb the kinetic energies of meteoroids or debris that strike them would be attached to each segment of the shield. Damaged panels could be replaced quickly and easily by an astronaut.

The four segments would be joined by butterfly hinges that would fold to allow the shield to be compressed to a diameter of 175 in. (444.5 cm) so that it would fit into the cargo bay of the Space Shuttle. Four bands would compress the segments securely to prevent vibration during launch. Once the stowed shield was in orbit, the bands would be released and the hinges opened, expanding the shield to a diameter of 183 in. (464.8 cm) so that it could be slipped over a space-station module and fastened to it with flexible closure elements.

The lattice structure would flex between the smaller and larger cylindrical radii during deployment but would have relatively high longitudinal stiffness. Part of the force of deployment would be provided by spring actuators in the butterfly hinges. In comparison with electric motors or pneumatic actuators, the springs would be simple, would furnish large forces, would be lightweight, and would consume no power during deployment.

This work was done by John W. Redmon, Jr., Bobby E. Lawson, Andre E. Miller, and W. E. Cobb of **Marshall Space Flight Center**. *To obtain a copy of the report, "A Light-Weight, Thermally Isolated Deployable Meteoroid/Debris Shield for Cylindrically Shaped Spacecraft," Circle 116 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 18]. Refer to MFS-28524.

Three-Dimensional Turbulent Boundary Layer With Adverse Pressure Gradient

Flow is measured on a cylindrical model with a forward-facing step.

A report describes an experiment to measure the effects of adverse pressure gradient on three-dimensional turbulent boundary-layer flow. This is part of a continuing series of experiments designed to study the details of turbulent boundary-layer flow in the interest of improving predictive techniques for lift and drag on aerodynamic and hydrodynamic vehicles. In this case, the effect of the streamwise gradient of pressure on the crossflow is of particular interest.

The experiment was conducted on a 14-cm-diameter cylinder, the axis of symmetry of which was aligned with the wind tunnel. An upstream section of the cylinder 91.4 cm long was made to spin, thus producing a lateral flow within the boundary layer, while an adjacent downstream section 91.4 cm long was held stationary. A forward-facing step, 2.54 cm high, was added by mounting an annular sleeve on the stationary section 15.4 cm downstream of the junction between the stationary and rotating sections. This step produced the adverse streamwise pressure gradient.

The wind tunnel was operated at a free-stream velocity of 36.5 m/s and at ambient temperature and pressure. The flow field along and around the cylinder was measured by two- and three-dimensional laser Doppler velocimetry. Surface pressures were also measured. Measurements were concentrated along the stationary section, where the boundary layer was reacting to the abrupt change in boundary conditions (from spinning to nonspinning).

The mean and fluctuating velocity measurements obtained with the laser were used to determine streamline patterns, production, and dissipation of kinetic energy. The data was used to test the accuracy of a variety of turbulence modeling assumptions used in modeling the turbulent Reynolds stress forces. Turbulent Prandtl mixing lengths were extracted from the data, showing the effects of curvature.

The streamwise flow was found to be driven predominantly by pressure forces; viscous forces became important only near the wall. The increase in pressure was found to occur over such a short

distance that the turbulent stresses were barely able to respond before the flow separated. The transverse components of mean flow and Reynolds shear stress seemed to be insensitive to the streamwise gradient of pressure. Transverse strain was found to reduce the streamwise component of Reynolds stress for both zero- and adverse-pressure-gradient flow cases.

The production of turbulent kinetic energy was found to grow rapidly in the vicinity of the step as the result of steep mean-flow velocity gradients. Dissipation was found to grow less quickly than production; this led to a net growth with distance along a streamline.

This work was done by David M. Driver of **Ames Research Center** *and Sheshagiri K. Hebbar of the Naval Postgraduate School. To obtain a copy of the report, "Three-Dimensional Shear-Driven Boundary Layer Flow With Streamwise Adverse Pressure Gradient," Circle 22 on the TSP Request Card. ARC-12331*

Coping With Vibrations in a Multiple-Payload Platform

Methods of isolation, suppression, and compensation are discussed.

A paper discusses some engineering methods of coping with vibrations in a large platform (e.g., a space station or smaller spacecraft) that supports multiple articulated scientific instruments. The basic problem is to enable every instrument to maintain accurate aim in the presence of disturbances caused by motions of other instruments, operation of other machinery, sloshing of fuel, movements of crewmembers, orbital/gravitational librations of the platform, and controlled maneuvers of the platform. Although the paper approaches the problem from the spacecraft perspective, it also has considerable value as an introductory text on the general problem of aiming instruments and minimizing the effects of vibrations in a large structure.

After describing the vibrational disturbances expected to occur in a representative space platform, the paper indicates that the solution to the basic problem requires the coordination of three engineering approaches: suppressing vibrations, isolating vibrations, and compensating for vibrations. In the vibration-suppression approach, passive damping elements and/or actuator and sensor elements connected to a control system are added to the platform at strategic points to reduce disturbances over the whole platform.

In the vibration-compensation approach, the vibrations of the platform at the positions of the instruments are sensed and/or computed, and compensatory vibrations are applied to the actuators that aim each instrument. Thus, the instrument can be aimed accurately even though the platform is vibrating strongly. Vibration-compensation techniques can be applied to existing instrument-mounting hardware. Like the vibration-suppression approach, the vibration-compensation approach requires the use of active-control techniques, including possibly substantial computational capability.

The vibration-isolation approach can involve the use of active and/or passive techniques as in the vibration-suppression approach, but unlike in the vibration-suppression approach, the objective is not to suppress vibrations throughout the platform. Instead, the objective is to reduce the coupling of vibrations into those parts of the platform that support instruments that must be aimed precisely and/or to prevent the transmission of vibrations from sources of disturbance to the rest of the platform while allowing other, non-vibration-critical parts of the platform to vibrate. In a typical case, the vibration-isolation mechanism is an active or passive interface that is soft in the frequency range of the expected disturbances.

The paper goes on to discuss engineering tradeoffs within and among the suppression, compensation, and isolation approaches. There are brief discussions of the mechanics of passive isolators and of

how to tailor the frequency responses of active isolators. Examples of passive and active isolators are presented. Plans for further development of multiple-payload platforms designed to minimize the effects of vibrations are described.

This work was done by Samuel W. Sirlin of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Vibration Isolation Versus Vibration Compensation on Multiple Payload Platforms," Circle 7 on the TSP Request Card.*
NPO-18021

Effects of Compressibility on Dynamic Stall

Effects of compressibility are noticeable even at speeds as low as mach 0.2.

A report presents the results of computations and measurements of compressible flow about an airfoil, the angle of attack of which oscillates about the static-stall angle. The study focuses on the effects of compressibility on dynamic stall. Of particular interest are the conditions that determine the onset of separation of flow, which can lead to premature dynamic stall and a consequent significant reduction of lift.

For the sake of discussion, flows are classified into three regimes: (1) the attached-flow regime, in which the effects of viscosity are confined to the boundary layer and the outer flow can be considered inviscid; (2) the separated-flow regime, in which the boundary layer has broken down, forming large eddies that dominate the flow; and (3) the reattachment regime — a transient regime that occurs after most of the vortexes have moved downstream of the trailing edge and during which the flow recovers to a status close to that of the static flow that would occur at the same angle of incidence. The flows described in the report are mostly in the attached-flow regime.

The dependence of the critical mach number on the curvature of the leading edge, the camber, and the angle of attack is investigated. Three sets of pressure-history data for three different free-stream mach numbers are discussed to exemplify typical effects of the frequency of oscillation on the flow in the attached-flow regime. It is shown that the effects of frequency on the onset of stall are different, depending on whether the flow has locally exceeded sonic conditions during part of the cycle of oscillation. A review of classical theories on the dynamics of compressible flow provides a basis for predicting the conditions under which a flow becomes mach-critical; i.e., the maximum local speed of flow exceeds the local speed of sound.

From the observed and computed behavior of the flow before separation, the authors conclude that the outer flow is quasi-steady until separation. In a subcritical flow, increasing the frequency of oscillation delays separation of the boundary layer and thereby allows the airfoil to attain higher lift at higher angles of attack. However, as the airfoil assumes values of lift higher than the value at static stall, the flow around it can easily become supercritical. A local supersonic region and the associated shock can form close to the leading edge, where the radius of curvature is small.

The vortical content of the flow is intensified because of the relatively short extension of the local supersonic region. The outer flow, which has been keeping the boundary layer from detaching, is no longer stable. The numerically predicted conditions under which the outer flow becomes unstable are close to those found in a wide range of dynamic-stall experiments. Finally, the authors conclude that a new mechanism, which can be related to the shock-generated vorticity, may be responsible for the change in the character of separation of a dynamically stalling airfoil. Hence, it is important to consider the effects of compressibility even at free-stream mach numbers as low as 0.2.

This work was done by L. W. Carr of **Ames Research Center** *and K.-Y. Fung*

of the University of Arizona. To obtain a copy of the report, "The Effects of Compressibility on Dynamic Stall," Circle 35 on the TSP Request Card.
ARC-12473

High-Resolution Shock-Capturing Schemes for a Real Gas

Methods for the solution of the equations of one-dimensional flow are compared.

A report presents a comparative study of several high-resolution explicit numerical-simulation schemes that capture shocks in one-dimensional flows of a real gas. (One-dimensional shock-tube problems are called "Riemann problems.") In this study, the various one-dimensional schemes are compared with respect to (1) ability to capture shocks, (2) resolution of shocks, (3) overall accuracy, and (4) computational efficiency.

The Euler equations for the conservation of mass, momentum, and energy in one-dimensional flow are presented. Thermodynamic derivatives that express the properties of the gas are introduced into these equations via a Jacobian matrix in a matrix•vector formulation that is commonly used in Riemann solvers. Three Riemann solvers are presented. The first is an approximate one based on a generalization, to a real gas, of a perfect-gas function called the Roe average, which is valued for its simplicity and its ability to satisfy the jump conditions. The second Riemann solver is a generalization of the flux-vector-splitting technique developed by Steger and Warming for a perfect gas. The third Riemann solver is a real-gas generalization of the perfect-gas flux-vector-splitting technique developed by van Leer.

Five numerical-integration algorithms formed from combinations of numerical-integration schemes with Riemann solvers are presented. These algorithms belong to the class of total-variation-diminishing explicit schemes and are divided into two subclasses: those that take the MUSCL approach and those that take the non-MUSCL approach. The non-MUSCL algorithms are a second-order symmetric and a second-order upwind numerical-integration scheme that incorporate the approximate Riemann solver. The MUSCL algorithms include an upwind numerical-integration scheme with the approximate Riemann solver and the other two Riemann solvers: one with the generalized Steger-Warming flux-vector splitting and one with the generalized van Leer flux-vector splitting.

The five schemes are applied to six different Riemann problems for equilibrium air with various ranges of mach numbers, densities, and pressures. The numerical results in the supersonic and low-hypersonic regimes indicate that these approaches offer good shock-capturing capability and that the resolution of the shock is affected only slightly by the equation of state of equilibrium air. The difference in resolution between the various schemes varies slightly from one Riemann problem to another, but the overall accuracy is very similar. For the one-dimensional case, all the schemes require about a comparable number of arithmetical operations. The main difference between the methods lies in their extendability to multidimensional problems with efficient implicit solution procedures.

This work was done by L. L. Montagne, H. C. Yee, and M. Vinokur of **Ames Research Center**. *Further information may be found in NASA TM-100004 [N87-27470], "Comparative Study of High-Resolution Shock-Capturing Schemes for a Real Gas."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12438

Machinery

Thermal-to-Electric Converter With Greater Power Density

Heat could be fed-in at lower temperature.

NASA's Jet Propulsion Laboratory, Pasadena, California

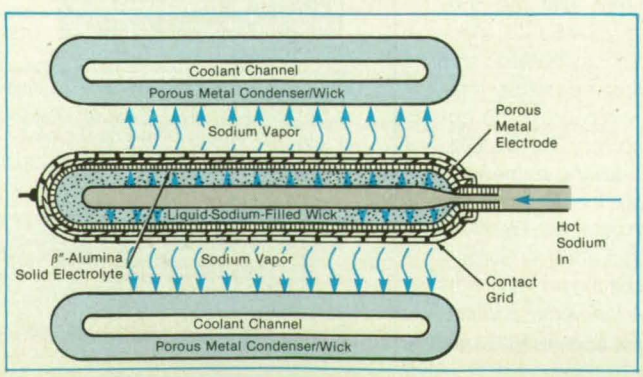
A proposed design for an alkali-metal thermal-to-electric converter (AMTEC) would incorporate several refinements to increase the power density and to reduce the input temperature below that of a typical prior design. Preliminary calculations indicate that the output electrical power per unit volume of converter would lie in the range of 0.5 to 1.0 kW/L for input and output temperatures in the ranges of 800 to 1,100 and 400 to 700 K, respectively. These improvements would be effected by use of techniques that have not previously been applied to the fabrication of AMTEC cells.

Each cell of the converter (see figure) would include a layer of β''-alumina solid electrolyte, one side of which would be in contact with a liquid-sodium-filled wick. Hot sodium would be pumped through the cell, and it would be wicked to the surface of the solid electrolyte, where it would give up electrons. The electrons would be conducted to external circuitry through the hot-sodium-feedthrough tubes, and the sodium ions would pass through the solid electrolyte. On the other side of the electrolyte, a porous metal electrode (typically of molybdenum, tungsten, or an alloy of tungsten) would supply electrons to recombine with the sodium ions. The electrons would be supplied to the thin porous electrode from external circuitry by a metal contact grid, possibly of the same material as that of the porous metal electrode.

The neutralized sodium would evaporate from the electrolyte/porous-electrode interface, travel through the electrode, and be condensed on porous metal wicks (possibly identical to the porous electrode) a short distance from, but not in electrical contact with, the electrolyte, porous electrode, and grid. The AMTEC cells could also be stacked with a small spacing between individual cells, and the wick condensers would be placed around the stack of cells. The condensed sodium would flow through the wicks to a slightly cooler collection volume and be recirculated to the source of heat. The coolant in the condensers could be liquid sodium (typically at a temperature $\geq$373 K) or another suitable fluid. The coolant, wick, electrode, and contact materials would all be chosen with regard to chemical and thermomechanical compatibility with the hot sodium and β''-alumina.

In fabrication, the β''-alumina solid electrolyte would be tape-cast on both sides of a flat porous metal wick; this would reduce both the thickness of the cell and the internal series electrical resistance below those of prior designs. The contact grid would consist of (1) a microscopic mesh formed by photodeposition either over or under the porous metal electrode and (2) an overlying macroscopic mesh in contact with the microscopic mesh. The planar configuration would enable the most efficient arrangement of cells and condensers.

This work was done by Roger M. Williams, Jerry W. Suitor, Barbara Jeffries-Nakamura, Mark L. Underwood, Margaret A. Ryan, and Dennis O'Connor of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 100 on the TSP Request Card.*
NPO-18197



The Proposed **Alkali-Metal Thermal-to-Electric Converter** (one cell is shown here) would have a compact, planar configuration. Planar cells could be stacked densely with remote condenser for thermal efficiency and high power density. Either liquid-or vapor-fed cells could be utilized.

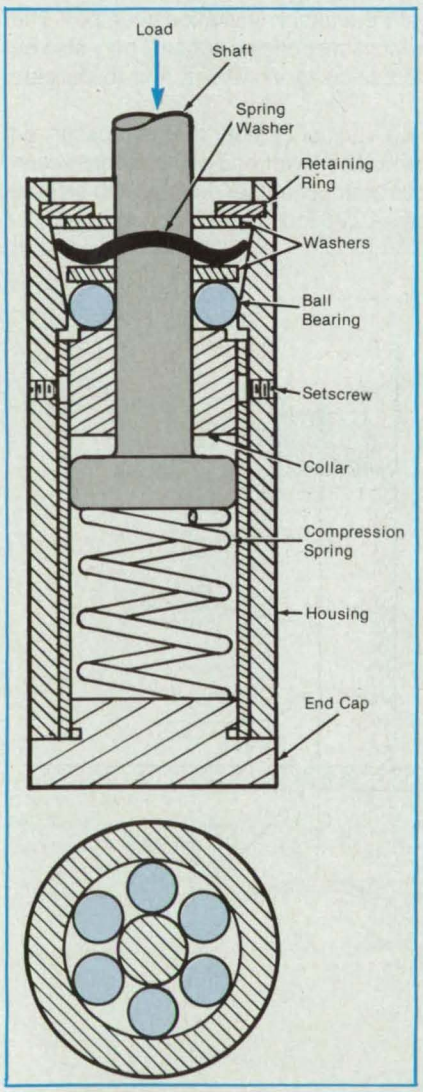
Self-Resetting Energy Absorber

After absorbing a shock, the mechanism immediately readies itself for another.

Lyndon B. Johnson Space Center, Houston, Texas

A mechanical device absorbs the kinetic energy of a moving mass and automatically resets itself so that it is ready for another impact. Unlike hydraulic shock absorbers, the new device is compact and not subject to leakage of hydraulic fluid. Unlike friction-washer shock absorbers, the new device resets itself, and its damping force can be adjusted easily. The device could be used to absorb mechanical shocks in industrial machinery, automobile bumpers and suspensions, and parachute lanyards, for example.

The device uses friction to dissipate kinetic energy. When the moving mass pushes it in one direction, it offers substantial friction. Pushed in the opposite direction, it offers negligible friction. Therefore, a built-in spring can reset it for another shock-absorption cycle.



The **Shaft Slides** downward and upward in the housing. On the downward stroke, the ball bearings exert a high frictional force on the rod. On the upward stroke, friction is much smaller. Alternatives to the ball bearings as friction-generating elements are wedges, a cantilevered beam, or levers.

The device (see figure) includes a housing, which is mounted on an external support. A shaft accepts the load from the moving mass, translating and compressing a spring against the end cap of the housing as it does. In translating, the shaft moves through a set of ball bearings. The movement of the shaft carries the balls along in a tapered sleeve. As they fit tighter in the sleeve, the balls apply increasing friction to the shaft. When they seat on a collar, the balls exert a nearly constant frictional force on the shaft. They thus retard the movement of the shaft, absorbing the kinetic energy. When the shaft comes to rest, the compressed spring expands and restores the rod to its original position.

A wave spring between a pair of washers applies a small preload to the ball bearings. The axial position of the collar within the housing can be adjusted to adjust the distance the balls travel along the tapered sleeve during a stoke of the rod. Moving the collar up gives a looser fit, and moving it down gives a tighter fit in the tapered sleeve. The adjustment of the collar thus adjusts the tightness of the bearing and, therefore, the frictional force and the amount of energy absorbed.

The rod, sleeve, and ball bearings are made of surface-hardened steel to ensure smooth movement and prevent seizure and galling. Tests of a prototype device showed that the force on the shaft increases rapidly to a maximum (the point at which the balls seat on the collar) and remains nearly constant during the rest of the stroke, without the load spikes that would indicate sticking. The load-versus-stroke behavior of the device was observed not to change with temperature over the range from −33 °F (−36 °C) to +178 °F (81 °C). The tests also showed that the load during reset is negligible. This is as expected, inasmuch as the compressed reset spring moves the balls in the direction of widening taper.

This work was done by Horacio M. de la Fuente, Kornel Nagy, and Clarence J. Wesselski of **Johnson Space Center**. *For further information, Circle 58 on the TSP Request Card.*

This invention is owned by NASA, and a

patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 18]. Refer to MSC-21555.

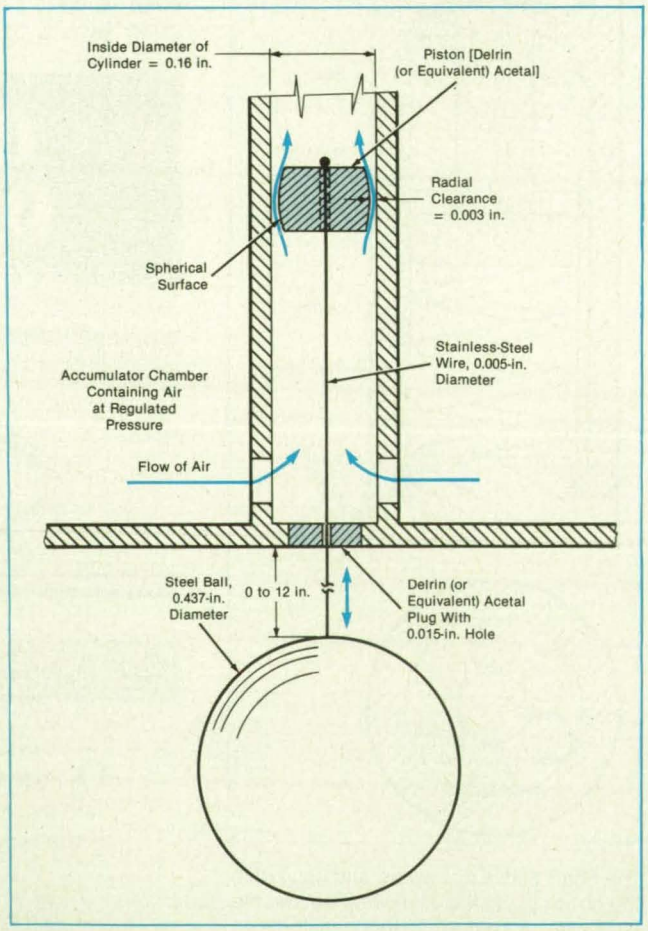
Air-Bearing-Piston Suspension System

Features include low translational and rotational friction and nearly zero vertical acceleration.

NASA's Jet Propulsion Laboratory, Pasadena, California

A suspension system based on an air-bearing piston holds up a steel ball against gravitation while allowing the ball to translate freely as much as 12 in. (30.5 cm) in a vertical direction and to rotate freely about a vertical axis. The system also allows the ball some limited horizontal movement. The system was designed to simulate the effect of microgravity on the steel ball, which represents a specimen to be processed in orbit in a high-temperature acoustic-levitation chamber. The particular air-bearing-piston suspension concept may also be applicable to the suppression of vibrations and to delicate machining processes.

The piston slides in a vertical cylinder that is pressurized with air from its lower end. The lower end of the cylinder communicates with an accumulator chamber that helps to smooth out variations in pressure caused by sudden large vertical



The **Air-Bearing Piston** counteracts its own weight as well as the weights of the wire and the ball but still allows the ball to move up and down freely and rotate freely about its vertical axis. To enhance clarity, this diagram is simplified and is not drawn to scale.

movements of the piston. A stainless-steel wire suspends the ball from the piston. The wire passes through a hole at the bottom of the cylinder (see figure).

The surface of the piston is spherical, and there is a radial clearance of 0.003 in. (0.08 mm) between the piston and the wall of the cylinder. The venturi effect in the upward flow of air between the piston and the wall centers the piston, and the flowing air thereby acts as a low-friction air bearing. The compressed air also exhausts through the 0.005-in. (0.13-mm) radial clearance between the wire and the bottom hole, reducing the friction between the wire and the hole. The horizontal movement of the ball is subject to the pendulum effect in the portion of the wire below the hole.

The pressure in the accumulator chamber and cylinder is regulated by a mechanical regulator (which is to be replaced eventually by a regulator controlled electronically by feedback from a strain-gauge pressure sensor). The pressure is set at a nominal value at which the piston force counteracts the weights of the piston, wire, and ball.

Preliminary measurements with a sphere 0.437 in. (11.1 mm) in diameter show that the system nulls the effect of the normal terrestrial gravitation (g) to $\lesssim$ 0.001 g and produces a vertical frictional acceleration $\approx$ 0.001 g. The frictional rotational deceleration at the radius of gyration of the sphere was found to be only 89 μg. The pendulum effect with a wire protruding 6 in. (152.4 mm) was found to be equivalent to a centering acceleration of 0.0066 g at an off-axis displacement of 1 mm. The additional friction between the wire and the bottom hole at this displacement was found to increase the vertical frictional acceleration by 0.001 to 0.002 g.

This work was done by Donald Mullen and Stephen J. Bishop of Loral Electro-Optical Systems, Inc., for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 4 on the TSP Request Card.*
NPO-18138

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Future V/STOL Aircraft for the Pacific Basin

New configurations can benefit commerce, tourism, and the development of resources.

Advanced aircraft offer new opportunities for short-haul transportation in the Pacific Basin, a report finds. The report describes the geography and transportation needs of the Asian Pacific region, including Indonesia, Oceania, Australia, and Japan. It discusses opportunities in both low-population and high-populations areas. It describes new and proposed aircraft configurations suitable for the region and compares their performances.

The report examines potential applications of high-speed rotorcraft, vertical/short-takeoff-and-landing (V/STOL) aircraft, and short-takeoff-and-landing (STOL) aircraft. Advances in materials, propulsion, aerodynamics, controls, and guidance are yielding promising new designs.

Revenue passenger miles from the United States to the Asian Pacific region are expected to grow by as much as 370 percent by the year 2000, the report notes. Rotorcraft and STOL and V/STOL aircraft can serve in congested cities as well as on remote islands. All of these vehicles can contribute to growth in combination with conventional aircraft.

The potential applications are the following:

- Commuter airlines, which would help to relieve congestion at large airports, where economics and low noise are important;
- Tourism, where ease of preparation of landing surfaces, low costs, and low noise are important;
- Transportation of valuable cargoes, where speed and range are factors;
- Development of such resources as fishing, high-grade mining, and the extraction of oil;
- Utility transportation in developing regions;
- Public service, including law enforcement, air ambulances, fire fighting, and disaster relief.

The greatest opportunities appear to be for smaller vehicles — those carrying fewer than 50 passengers. Operating ranges vary from 300 to 3,000 nautical miles (about 560 to 5,600 kilometers). Other characteristics that determine applicability are productivity (speed and payload), fuel efficiency, ability to hover, economics, noise, and downwash.

This work was done by James A. Albers and John Zuk of **Ames Research Center**. *Further information may be found in NASA TM-100005 [N88-11644], "V/STOL Aircraft Configurations and Opportunities in the Pacific Basin."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12177

Fabrication Technology

Hardware, Techniques, and Processes

Noncontaminating Borescope Viewing Fixture

All parts are made of stainless steel.

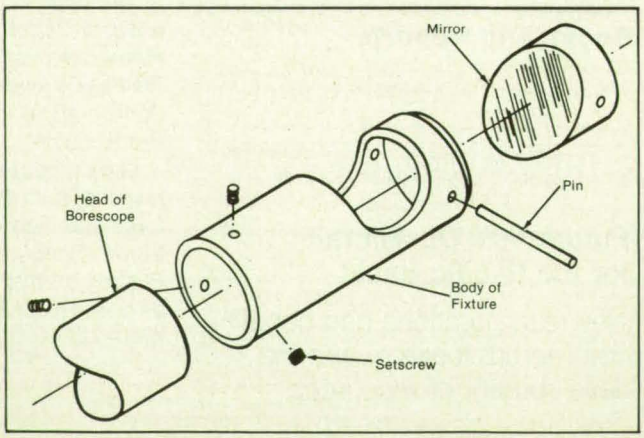
Marshall Space Flight Center, Alabama

An all-stainless-steel viewing fixture for a borescope can be used without fear of breakage or of contaminating internal cavities of equipment. The fixture fits over the conventional viewing head on a borescope. It can be used for internal inspections by visible illumination or visible fluorescence from ultraviolet illumination.

This fixture contains a stainless-steel mirror that can be built to any desired viewing angle (see figure). The mirror is polished to a finish of 2 μm and provides a sharp, distortion-free image. Unlike the conventional glass mirror, the solid metal mirror cannot shatter in the cavity being inspected and litter it with glass particles. If the metal mirror becomes scratched, it can be taken out of the fixture and repolished in a metallurgical-specimen holder. A scratched glass mirror, in contrast, must be discarded and replaced by a new one.

The stainless-steel parts do not rust or corrode in the cavity, even when the cavity contains liquid oxygen. Therefore, the fixture does not introduce contamination into the cavity. Because the fixture can withstand sterilization in an autoclave, it can be adapted to medical endoscopes.

This work was done by Orlando G. Molina and Richard K. Burley of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 129 on the TSP Request Card.*
MFS-29781



The **Viewing Fixture** fits on the end of a borescope. All parts, including the screws, pin, and mirror, are made of stainless steel.

Smooth-Surfaced Carbon/ Carbon Reflector Panels

The surface is covered with graphite foil, which is then densified.

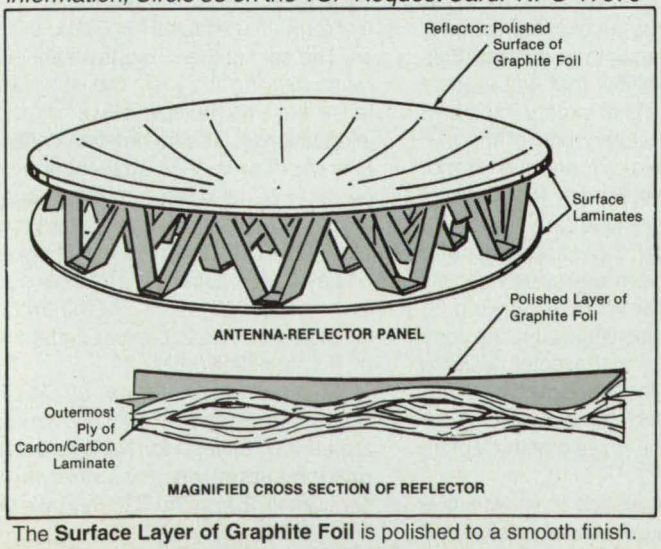
NASA's Jet Propulsion Laboratory, Pasadena, California

Work continues to develop reflective, lightweight, low-outgassing radio-antenna-reflector panels that include carbon/carbon surface laminates supported by carbon/carbon core structures. Essential to the fabrication of such a panel is a technique for the densification of the surface laminate in preparation for polishing to the final mirror surface. Densification is needed to prevent "print-through" of carbon fibers on the surface. Print-through occurs when the resin-impregnated carbon fabric destined to become the carbon/carbon composite is heat-treated at 2,200° C and the surface resin is decomposed, leaving exposed woven fabric. When the composite is properly densified, the surface can be polished to a smooth finish.

The surface-densification technique has to be an integral part of the fabrication process. The first step of this technique is to add an outer layer of graphite foil to the surface laminate during the preparation of the resin-impregnated carbon-fabric structure and to cure the bond between the outer layer and the underlying surface laminate along with the rest of the structure. After the cure and the subsequent heat treatment, the surface of the graphite foil is sprayed with fine graphite particles in a binder. Then the surface is polished to a 0.05μm finish (see figure). Alternatively, one can polish the surface, then spin-coat it with 10-μm-thick layer of polyimide in solvent. The thin, uniform film that remains after the solvent evaporates requires no further polishing. In yet another alternative and still largely experimental process, the graphite foil is coated with a thin layer of carbon by chemical-vapor deposition.

Regardless of which surface-finishing technique is selected, the graphite foil is thermally stable enough to withstand high temperatures in processing and is thermally stable in use. It stops the propagation of surface microcracks in the underlying carbon/carbon composite. Moreover, it seals the composite, preventing any loose carbon dust from leaking out.

This work was done by Wesley P. Schmitigal, Paul J. Jacoy, Christopher C. Porter, and Gregory S. Hickey of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 53 on the TSP Request Card. NPO-17979*



The **Surface Layer of Graphite Foil** is polished to a smooth finish.

Mathematics and Information Sciences

Algorithm Calculates Cumulative Poisson Distribution

Factors are inserted temporarily to prevent underflow and overflow

NASA's Jet Propulsion Laboratory, Pasadena, California

An algorithm calculates accurate values of the cumulative Poisson distribution under conditions in which other algorithms fail because numbers are so small (underflow) or so large (overflow) that a computer cannot process them. Both underflow and overflow can occur when the Poisson parameter is large; overflow can also occur when the number of terms is large. This algorithm prevents underflow in the first place and prevents incipient overflow by performing some simple auxiliary multiplications. The algorithm is implemented in the CUMPOIS computer program described in "Cumulative Poisson Distribution Program" (NPO-17714), *NASA Tech Briefs*, Vol. 14, No. 7, (1990) page 62.

The cumulative Poisson distribution for n terms and Poisson parameter (mean of the Poisson distribution) μ is given by

$$(1)\quad poif(n,\mu) = \sum_{j=0}^{n} e^{-\mu}\mu^j/j! = e^{-\mu}\left(1+\mu+\frac{\mu^2}{2!}+\frac{\mu^3}{3!}+\ldots\frac{\mu^n}{n!}\right)$$

Part of the algorithm is indicated by the form of the right side of equation (1). The summation is performed first, then the sum is multiplied by an exponential term involving μ and a factor to be detailed. This prevents the underflow that would likely occur in some terms at large μ if the $e^{-\mu}$ were factored into every one of them.

Individual terms $\mu^j/j!$, and the sum of them can still overflow in the form indicated on the right side of equation (1). To prevent overflow, individual terms and partial sums of them are systematically multiplied by a small factor as required. To recover the true value of the sum, the completed sum containing the factor raised to various powers is then multiplied by an exponential term in which the exponent contains the sum of the powers of the factors and $-\mu$.

The factor in question is e^f, which is chosen to be a number that is large, but not so large as to overflow. Each time the sum becomes so large in comparison with e^f that it threatens to overflow, the partial sum and the next term to be added to the partial sum are multiplied by e^{-f}. This procedure is represented by the following equation:

$$\begin{aligned}(2)\quad poif(n,\mu) = [(\ldots(((1+U_1+U_2+\ldots+ U_{r_1})e^{-f}+U_{r_1+1}+U_{r_1+2}+\ldots+ U_{r_2})e^{-f}+U_{r_2+1}+U_{r_2+2}+\ldots+ U_{r_3})e^{-f}+\ldots+U_{r_m+1}+U_{r_m+2}+\ldots+ U_{r_{m+1}})e^{-f}+U_{r_{m+1}+1}+U_{r_{m+1}+2}+\ldots+ U_n]e^{-\mu+mf}\end{aligned}$$

where the U_j's are defined by

$$(3)\quad U_j = U_{j-1}\frac{\mu}{j} \text{ for } j \neq r_{k+1} \text{ and } 0<k\leq m$$

$$(4)\quad U_j = U_{j-1}\frac{\mu}{j}e^{-f} \text{ for } j = r_{k+1} \text{ and } 0<k\leq m \text{ and } U_0 = 1$$

The process of summation begins with the unity term and continues until U_{r_1}, the first term after which e^f would be exceeded. The sum is then "made small" again by multiplying it by e^f. The subsequent terms are also multiplied by e^f as shown in equation (4). The summation continues until overflow is once again about to occur, after U_{r_2}, and the summation and the next term are factored again. This process continues until all of the terms in equation (2) have been summed. The final sum is then multiplied by $e^{-\mu+mf}$. (The exponent is calculated first to prevent underflow of $e^{-\mu}$ or overflow of e^{mf}.)

This work was done by Paul N. Bowerman, Robert C. Nolty, and Ernest M. Scheuer of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 151 on the TSP Request Card. NPO-17915*

Introducing Power Windows For Project Managers.

The #1 Rated Project Manager Now Available For Windows.

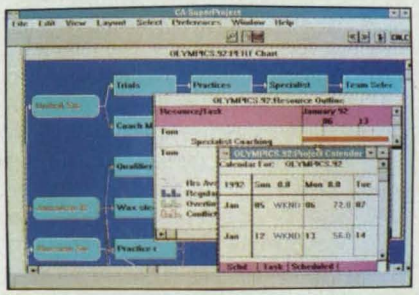
Power changes people.
Especially project managers.

They're working smarter and faster with new CA-SuperProject® For Windows.

It's the world's most advanced, efficient and reliable project management software – and now it's incredibly easy to use.

Total power is yours with just a few mouse clicks. Create and edit projects. Specify resources, task types and durations. Define integrated sub-projects. Build top-down hierarchies and task-

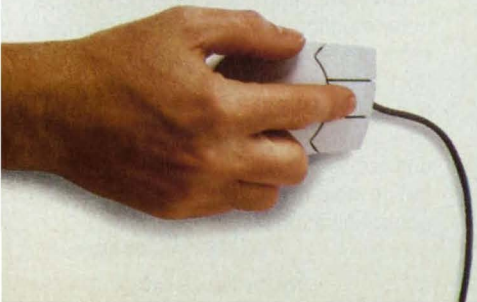
1992 W 100 WINDOWS MAGAZINE ANNUAL WIN AWARD

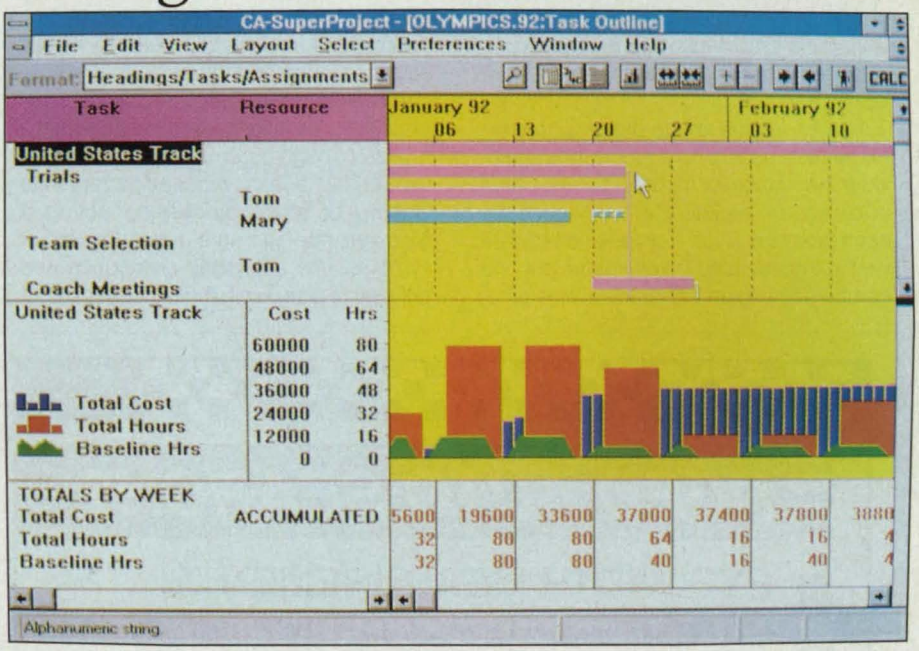


Report the status of your project with detailed Gantt, PERT, WBS and Cost/Resource charts.

dependency relations. Link multiple projects together for cross-project leveling. Perform extensive "what-if" analysis, revising schedules as projects progress.

You can bet your career on its



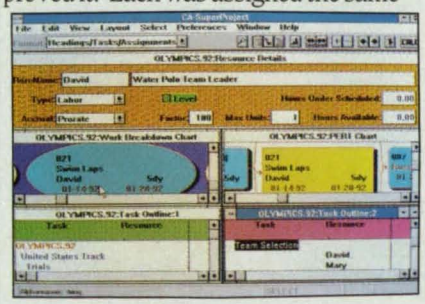


Manage with power, using tools for sophisticated planning, comprehensive resource management, tracking and controlling.

advanced and efficient scheduling algorithms.

MICROSOFT® WINDOWS™

A recent study of the five leading project managers proved it. Each was assigned the same



Show multiple views of the same project or different projects simultaneously.

project, but the finish dates varied by as much as five months. CA-SuperProject For Windows finished first in 214 working days–leaving Microsoft Project, Timeline 4.0, Project Workbench and Project Scheduler in the dust.

Free Demo Disk

There's also a wide array of state-of-the-art graphics and detailed reporting tools to help bring your projects to life.

For your free Demo Disk, call 1-800-CALL CAI. Call today.

And find out what our power windows can do for you.

COMPUTER® ASSOCIATES
Software superior by design.

CA-SuperProject® For Windows

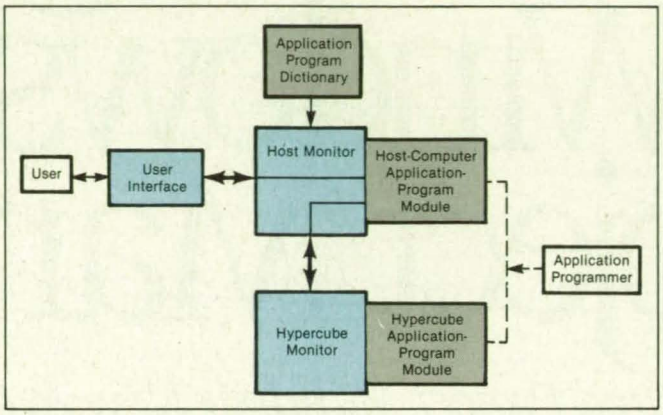
Image-Processing Software for a Hypercube Computer

Programmers need not be concerned with the complexities of computing-system architecture.

NASA's Jet Propulsion Laboratory, Pasadena, California

The Concurrent Image Processing Executive (CIPE) is a software system intended to facilitate both the development and the use of image-processing application programs on a concurrent computing environment. CIPE is designed to shield the programmer from the complexities of the concurrent-system architecture and to provide an interactive image-processing environment for the end user. CIPE utilizes architectural characteristics of a particular concurrent system (connection topology, local memory, etc.) to maximize efficiency while preserving architectural independence from the user and application programmer. The current implementation of CIPE runs on a Mark-IIIfp 8-node hypercube computer and the associated SUN-4 host computer.

In a traditional image-processing environment, a user runs a program and provides file names for input and output, thus involving an explicit file transaction for each program. Such manipulation of data via file transactions is very inefficient and cumbersome in an interactive image-processing environment. In CIPE, image-processing programs and data sets are viewed as subroutines and variables that a user can manipulate interactively without explicit file transactions. CIPE provides these effects through a combination of interactive user-interface modes, incremental loading of image-processing software modules, management of data by use of symbols, and automatic distribution and retrieval of data within the concurrent processing subsystem.



The **Concurrent Image Processing Executive** (CIPE) software system provides an architecture-independent environment for the development of image-processing application programs. This diagram shows the overall structure of CIPE and the relations among CIPE, the user, and the programmer.

CIPE offers a simple set of routines for interacting with the user, specifying distributions of data, activating application functions, and communicating parameters. These routines shield an application programmer from various user interfaces, file transactions, and architectural complexities.

CIPE includes three major interconnected components: the host monitor, the user interface, and the hypercube monitor (see figure). The host monitor manages image-processing functions, data sets, display devices, and interaction with the hypercube monitor.

CIPE's user interface provides a command-line interpreter, menus, and X-based windowing. The command-line interpreter functions as a shell-like interactive programming environment. The menu interface provides the user with a hierarchical organization of functions and interactive parameter processing. The windowing interface is similar to the menu interface except it allows direct access to the function hierarchy and mouse-oriented user input. User requests are translated into CIPE-function calls. The activated user interface is transparent to application programs.

The hypercube monitor contains the portion of CIPE that is specific to the hypercube. Application programs in a concurrent system with a Mark-IIIfp hypercube as a coprocessor are composed of host and hypercube portions. It can be a complicated and tedious task to coordinate between the two in the context of an interactive computing environment. The hypercube monitor was designed to provide a more transparent coordination between host and hypercube, so that an application programmer can treat the hypercube as a high-performance subroutine engine and not devote additional programming effort to host-cube coordination and data communication.

(Continued on page 147)

ISY '92

International Space Year

Special Advertising
Supplement To
NASA Tech Briefs

Photo: Bernard Paris, © Arianespace 1992

ISY '92

Special Report

International Space Year (ISY) 1992 is a global celebration of space cooperation, discovery, exploration, and education. In 1985, the late senator Spark Matsunaga from Hawaii proposed ISY '92 to commemorate the 500th anniversary of Columbus' discovery of the new world and the 35th anniversary of the International Geophysical Year that ushered in the space age. Today, it has blossomed into a worldwide space activity.

This special 48-page section spotlights aerospace leaders in Europe and the United States who embody the themes and share the goals of ISY '92. They include:

Aerospatiale
Agenzia Spaziale Italiana
Alcatel Space Division
Alenia Spazio
Allied-Signal Aerospace Co.
AMP, Inc.
Arianespace
Brunswick Defense
Centre National d'Etudes Spatiales (CNES)
Computer Sciences Corp.
DARA GmbH
Dassault
Ensign-Bickford Aerospace
Hughes Aircraft Co.
Instrumentation Marketing Corp.
Matra Marconi Space
Melcor
Mikron Instrument Co.
Miller Thermal, Inc.
National Technical Systems
Novespace
OHB-System
SNPE
Teledyne Relays/Solid State
Telespazio

Together, they are helping us to better understand our planet and, like Columbus, to discover new worlds, which in turn will reap benefits to life on Earth.

Message From Jean-Marie Luton, ESA Director General:

Jean-Marie Luton

Nearly six months after the November ministerial-level meeting of the ESA board in Munich, I am persuaded that, thanks to the political resolve and technological capacity of the ESA member countries, we are on the right track, approaching the end of this millenium with optimal advantages. Whether in terms of cooperation with the United States, Russia, Japan, and other countries, or of the development of wholly European programs, ESA is an active force.

Our presence and our actions must be beneficial not only to the aerospace industry but also to European industries that, through technology transfer, are developing and profiting from business in fields not directly related to space. They too are helping to promote Europe.

Europe In Space: Expanding International Cooperation

Paul Quiles

On December 19, 1961, the French parliament passed the law creating the Centre National d'Etudes Spatiales (CNES), France's space agency, which began operation in March 1962 with a staff of 17 people. Today, it employs nearly 2500 and its steadily growing budget approaches $2 billion. The agency has spawned a national industry developing launch vehicles and satellites.

Thanks to CNES, France is committed to major national and international programs involving launchers, application satellites, and scientific payloads. Through its impetus, Europe is on the way to achieving autonomy in the only field it has not yet conquered—manned space flight.

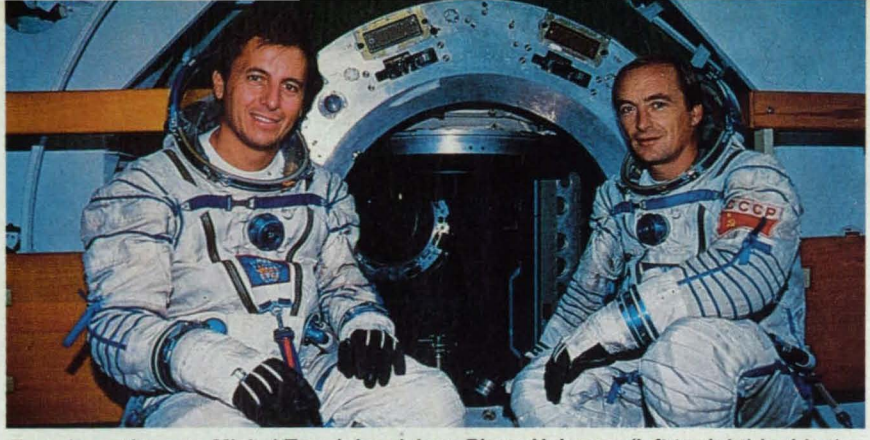
This policy, followed with perseverance over the last 30 years, has endowed France with mastery of the basic space technologies, most of which are so capital-intensive that they require a pan-European effort. This is especially true in the case of space flight. Without Europe behind it, Ariane never would have known the commercial success it currently enjoys.

Today, Europe knows how to get into space, but will not become a space power in the full sense of the term until it acquires the capability to return from space. That is why the European Space Agency (ESA) is committed to a large, balanced space program that, in addition to scientific investigation and environmental studies, is devoted to manned space flight.

Our pursuit of European autonomy goes hand in hand with our desire for cooperation with our partners in the East and West. This principle will be exemplified in 1992 by two events: the two-week flight of a French spationaut on the Mir space station, and the launching of the Topex-Poseidon oceanographic satellite—built by NASA with CNES' participation—on an Ariane rocket.

These resolute steps illustrate beautifully the themes of International Space Year.

Paul Quiles
Former Minister for Public Works, Housing, Transportation, and Space



French spationauts Michel Tognini and Jean-Pierre Haignere (left to right) inside the Mir space station simulator in Star City.

CNES Successfully Manages And Commercializes Space Technology

CNES, the French space agency, has grown over the past three decades to become an influential and highly competent agency with a skilled staff of more than 2400 and a budget this year of $1.8 billion, an increase of 7.4% over 1991.

Chaired by Jacques-Louis Lions and headed by Jean-Daniel Levi, CNES is Europe's leading space agency in terms of both capital and manpower. Its talent for selecting the right program at the right time and its ability to smoothly conduct its development (thanks to unwavering political support) have contributed greatly to its success. Among its recent achievements are the Spot, Telecom, and TDF satellites, and the Ariane family of launch vehicles. Now, CNES is sponsoring Europe's most ambitious program ever: the Hermes manned spaceplane.

What makes CNES unique among the world's space organizations, however, is its ability to create affiliates to commercialize technical developments. "The French space agency is keenly aware of the market potential of programs in which it is a prime contractor or participant," said Pierre Bescond, CNES' Director of Quality. "It has investigated setting up a number of private sector subsidiaries to market space products and services worldwide."

Mr. Bescond knows what he is talking about. Until recently, he was president of Spot Image Corporation, the American subsidiary of Spot Image, a French firm established by CNES to collect, process, and market remote sensing data.

CNES currently owns and operates 15 subsidiaries, the majority in France but also in the United States, Sweden, Australia, and Japan. They cover a broad range of businesses including space transportation (Arianespace), engineering and consulting services (Satel Conseil), remote sensing data acquisition and processing (Spot Image, Scot Conseil, and GDTA), positioning systems and data collection (CLS Argos), satellite testing (Intespace), microgravity services and technology transfer (Novespace), space equipment marketing (Prospace), and space medicine and physiology (MEDES/IMPS).

The most successful of these commercial ventures is Arianespace, the world's first commercial launch service company, founded in 1980 by CNES, 36 aerospace companies, and 13 banks from 11 ESA member states. This year, the company celebrates its fiftieth launch and hundredth launch contract.

Ariane illustrates perfectly the key to CNES' success: its ability to select strategic technologies needed to advance its space efforts and to develop these technologies in partnership within a European framework. A present example is the Hermes spaceplane, designed for mastering orbital transportation and reentry techniques for future European manned space systems. Another is the family of Earth observation systems that will use new European polar platforms to monitor environmental and climatic changes on a global scale. CNES, together with ESA and NASA, is contributing to the vital effort to better understand and care for our planet, which is the dominant theme of ISY '92.

Novespace's Earnings Skyrocket

Novespace, the CNES subsidiary responsible for technology transfer and promotion of microgravity, made an impressive gain of 68% in sales in 1991, with profits of about 7%. This growth stems directly from Novespace's efforts to bring European industries and the European Space Agency into the technology transfer arena, in the form of a European joint venture called GIE that teams Novespace with one German partner, MST, and one English partner, JRA. The new company's president is Jean-Pierre Fouquet, who also heads Novespace.

At the same time, Novespace's microgravity promotion continues, using for parabolic flights the Zero-G Caravelle, as well as Photon-type recoverable space capsules. The company is sponsoring an international conference on parabolic flights in Rome from December 9-11, 1992 to facilitate international exchanges on this subject.

With its international scope, Novespace is joining forces with many European, Japanese, Russian, and North American companies in both the microgravity and technology transfer businesses.

Novespace organizes parabolic flights aboard the Zero-G Caravelle for scientific experiments and research on weightlessness.

Arianespace Celebrates Its Hundredth Contract

An Ariane 40 rocket (without boosters) awaits firing on the launch pad in French Guiana.

Arianespace, the world's first commercial launch company, is celebrating a major milestone this month: its hundredth firm order for a satellite launch. This is an historic event for the European company chaired by Charles Bigot. Started some 12 years ago with rather modest expectations, the company has grown to be the world leader for commercial launches, with 50 Ariane rockets successfully launched to date.

In 1991, the company had a turnover of $1.2 billion and a profit of $25 million. As of late March, its order book with firm contracts included 31 satellites to be launched in coming years, a global value of about $2.5 billion.

Half of the satellites already orbited by Arianespace came from European states. The other half belong to about 20 foreign countries or organizations. Its largest customers are international satellite communications organizations, namely Intelsat, Inmarsat, and Eutelsat, as well as private satellite operators such as GTE-Spacenet Corp., GE Astro Space, and Hughes Communications, Inc.

Last year, eight Arianes lofted 11 satellites into orbit with great—and unmatched—accuracy. This year, Arianespace plans to launch another eight rockets carrying a dozen satellites, including the precious Topex-Poseidon, an experimental ocean observation satellite developed jointly by NASA and CNES. Slated for launch this summer, the oceanographic satellite was built by Fairchild Space, a subsidiary of Matra Espace. It is equipped with the first French radar altimeter, Poseidon, developed by another French space company, Alcatel Espace. It is the first time that a European rocket will launch a satellite built in cooperation with NASA.

This year also marks the introduction—slightly sooner than expected—of an improved version of Ariane 4 fitted with an enlarged cryogenic third stage. This upgraded Ariane 4 is designed to cope with the heavier commercial satellites planned for this decade. The rocket will be able to carry into geostationary transfer orbit a total payload mass of 4400 kg.

According to Charles Bigot, it will be the last enhancement of the current European launcher family. Starting in 1996, all Ariane 4s will be progressively replaced by the Ariane 5 heavy-lift rocket. By then, Arianespace expects to have secured half of the global commercial launch market, which, a recent study projects, could reach 200 satellites by the year 2003.

Aerospatiale Focuses On Hermes, Commercial And Military Satellites

Aerospatiale Espace and Defense Division's activities are divided between strategic ballistic missiles and space systems, including satellite and rocket design and manufacturing. According to Michel Delaye, head of the 5500-employee division, strategic missile systems represent 42% and space 58% of the division's business, which surpassed $1.5 billion worldwide in 1991. Due to two opposite effects—a decrease in orders for strategic missiles but growing interest in military satellites in France and Europe—space business should account for approximately 70% of the division's activity by 1994.

Already recognized as a leading European manufacturer of civil spacecraft (with 60 launched to date), Aerospatiale is determined to secure a dominant position in the French and European military satellite business. The Space Division manufactured the high-resolution optronic camera for the first French military observation satellite, Helios, planned for launch by Ariane in mid-1994. Now, it is preparing technical and financial proposals for developing new French optical and radar observation satellites as well as communications and ferret satellites.

Aerospatiale Espace and Defense has studied an improved version of Helios equipped with an infrared channel that will extend its daylight reconnaissance capability. Also, it has prepared answers to proposal requests to be issued this year concerning future French electronic listening satellites, known as Zenon, and radar observation satellites, dubbed Osiris. Its skilled team has expertise in producing observation satellites equipped with optical or infrared instruments. Its plant in Cannes could develop ferret and radar observation satellites in cooperation with traditional partners such as Alcatel Espace, Delaye said.

Aerospatiale recently established a closer association with Alcatel Espace, and Alenia Spazio of Italy, to create a formal teaming structure, the "Euro-Alliance," which they expanded by taking a 49% share in Space Systems/Loral (SS/L) of the United States.

According to Emmanuel Sartorius, the Space Division's satellite manager, the Euro-American Alliance is now the world leader for civil satellites—dominating even traditional American giants such as Hughes Aircraft and GE Astro Space—with a global market share of approximately 25%. Sartorius said that the goal of the Euro-American Alliance for the coming decade is to increase its share to one-third of the world's civil satellite market, estimated to reach 150 satellites (worth approximately $20 billion) by the year 2000.

The Alliance will reinforce Aerospatiale's position as the top manufacturer of satellites in Europe, said Delaye. In its first assignment under the agreement, Aerospatiale will develop a new three-axis bus for heavyweight satellites up to 3000 kg. It will complement Aerospatiale's family of existing platforms, Spacebus 1000 and 2000, and will reduce the cost of satellite platforms by about 20%.

The Alliance plans to balance worksharing between partners, including Space Systems/Loral. This principle is being applied to the N-Stars contract awarded to SS/L by

A vision of 2002: Hermes is lifted into the sky by an Ariane 5 rocket. Aerospatiale is leading the development of both the spaceplane and heavy-lift launcher.

SUCCESS IN THE AIR. SUCCESS IN SPACE. OUR NAME SAYS IT ALL. AEROSPATIALE.

EUTELSAT II

PUBLICIS - F C B ZBAS 35

As the chief architect of an entire range of spatial systems, from today's satellites to tomorrow's orbital space stations, AEROSPATIALE has, to date, sold 39 telecommunications and direct television broadcast satellites, 8 meteorological satellites and 28 satellites for the scientific observation of resources on Earth and in space.

AEROSPATIALE ploughs back more than 35% of its revenue into research and development. This percentage, the world's highest, places AEROSPATIALE firmly at the very heart of all major European aerospace research and development. From the outset, AEROSPATIALE's history has been marked by a series of international successes that are the fruit of true cooperation. One example is Ariane, with 50% of the launch vehicle market; another are the helicopters with a 40% share of world sales through the EUROCOPTER company. 70% of AEROSPATIALE's turnover is realized from programs which involve cooperation with other aerospace partners.

Within the context of a partnership built upon free exchange of information, methodology, technology and human resources, the US aerospace industry plays a leading role in a number of AEROSPATIALE aeronautical programs.

AEROSPATIALE

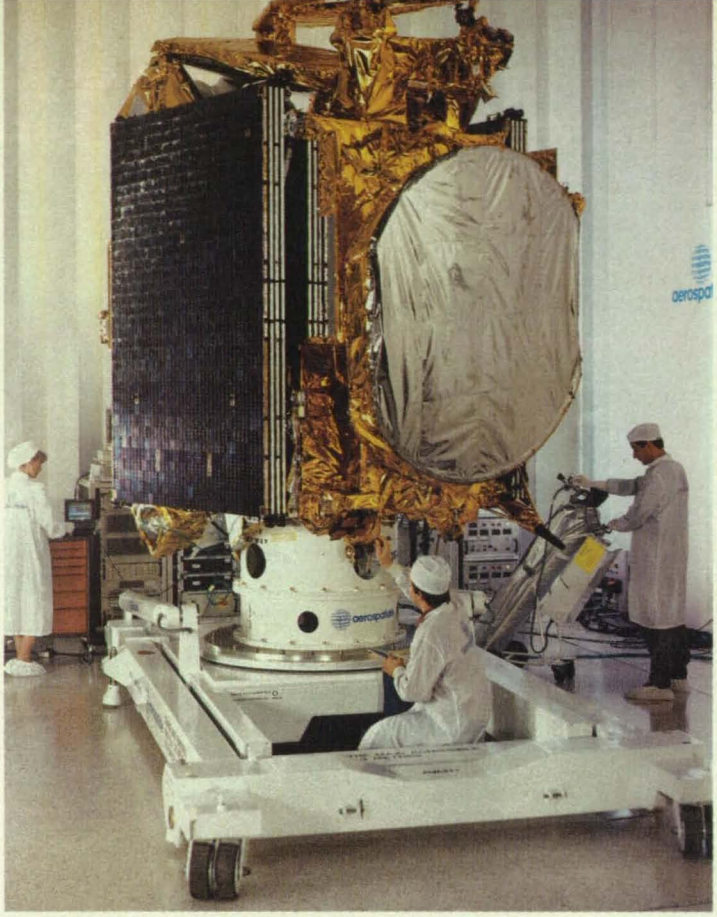
For More Information Circle No. 592

AEROSPATIALE INC. 1101 Fifteenth Street N. W. Washington, D. C. 20005-3099 - Telephone (202) 293-0650 - Telecopier (202) 429-0638

the Japanese operator NTT. Aerospatiale will manufacture composite structural elements of the two N-Star satellites, which will use Loral's Superbird 4000 kg platform. The 43-channel communications satellites will be launched in 1995.

The allied partners are also working together to secure new contracts. For instance, SS/L is leading the Alliance bid for Intelsat Follow-On Satellites (FOS), while in Japan, Aerospatiale drives the team looking for new spacecraft contracts from Satellite Japan Communications (SAJAC) and the Arab League. Other members are bidding in Iran and Argentina. Bids for these projects are based on using buses from Aerospatiale, and thus could extend the number of Spacebuses sold beyond the current 11, which include two Turksats, three Arabsats, and six Eutelsat 2s. The Turkish spacecraft will be the first placed in orbit by Aerospatiale, in 1993-1994.

Next year, Aerospatiale's Space Division will deliver the sixth Meteosat geostationary weather spacecraft, and negotiations are under way to provide two additional interim Meteosats. Sartorius expects to get the prime contract for the second generation of Meteosats, as well as for the European Polar Platform.



Aerospatiale is prime contractor for six Eutelsat 2 communications satellites. The Eutelsat 2 shown here is undergoing final tests in Aerospatiale's Cannes facility before being shipped to Guiana for launch.

Aerospatiale is prime contractor for two important European scientific space observatories: the Infrared Space Observatory (ISO), to be launched by Ariane in 1993, and the Huygens probe that will be carried on NASA'S Cassini spacecraft, planned for launch in 1997. Aerospatiale Espace and Defense developed ISO's huge helium-filled cryogenic structure, and applied ballistic reentry technology to design the aerodynamic shell for the Huygens probe, which will be dropped into the atmosphere of Titan.

Now, the company is hoping to win the contracts for Europe's new large astronomy satellites including the x-ray XMM and sub-millimeter FIRST. The team is also studying Marsnet, a network of small automated landers to be installed on Mars, and, with Alcatel Espace and Matra Marconi Space, is participating in the definition and tests of an autonomous Mars rover.

Upgraded cryogenic third stages of Ariane 4 await mating with other stages in Aerospatiale's Les Mureaux integration facility. The first flight of the H10+ stage took place this year.

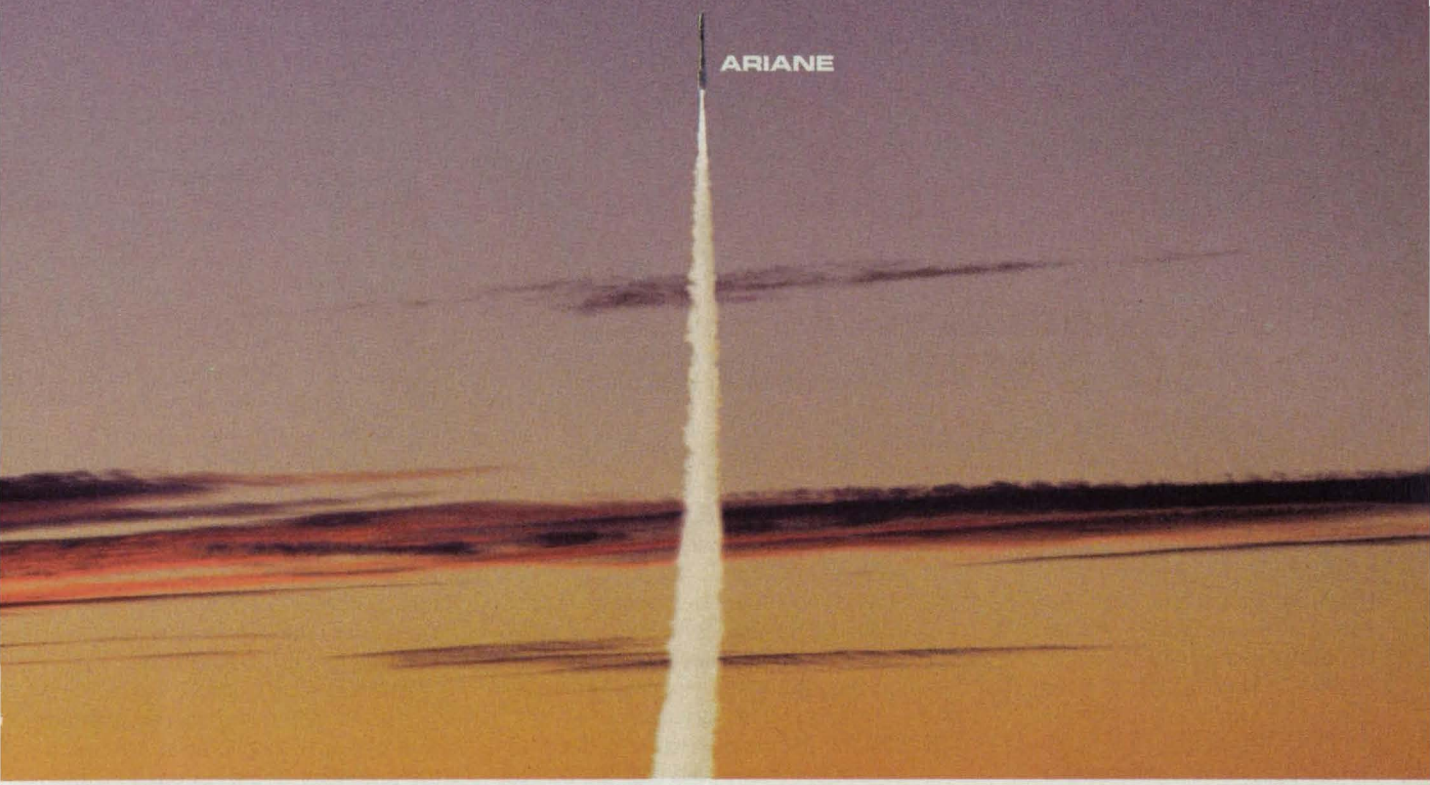
Aerospatiale is probably best known as a designer and manufacturer of space transportation systems, including Ariane rockets and the Hermes spaceplane. In Les Mureaux, near Paris, it is producing the Ariane 4 rocket, an improved version of which was flown in April. According to Guy Laslandes, Aerospatiale's AR4 manager, it took about three years to develop this new rocket, which features an H10+ (10 tons of Lox/LH2) cryogenic upper stage that increases AR44L's performance is geostationary orbit to 4450 kg.

"In the near-term, all Arianes will be H10+", said Francois Calaque, head of Aerospatiale's space transportation programs. From a systems standpoint, Calaque noted, the improved AR4 represents a quantum leap comparable to the transition from AR1 to AR3.

Concurrently, Calaque's team is developing the Ariane 5 heavy-lift rocket. Last December, it delivered the initial first stage tank, which is made of aluminum 2219 and designed to be filled with 157 tons of cryogenic propellant. The first test flight of the heavy-lifter is slated for late 1995.

Both the Aircraft and Space and Defense Divisions of Aerospatiale are heavily involved in the Hermes program through Euro-Hermespace, the prime-contracting company established last January to manage Hermes' development. The European manned spaceplane is targeted to make its first test flight in 2002 and to begin servicing space station Freedom in 2004.

SUCCESS IN THE AIR. SUCCESS IN SPACE. OUR NAME SAYS IT ALL. AEROSPATIALE.



Ariane accounts for 50% of the launch vehicle market. A product of AEROSPATIALE knowhow and design. 94 satellites are now scheduled for launch - 19 American, 3 Canadian and 45 European.

Chief architect of the Hermes European Space Shuttle program, AEROSPATIALE masters all aspects of aerospace systems from today's satellites to the orbital stations of tomorrow.

AEROSPATIALE ploughs back more than 35% of its revenue into research and development. This percentage, the world's highest, places AEROSPATIALE firmly at the very heart of all major European aerospace research and development. From the outset, AEROSPATIALE's history has been marked by a series of international successes that are the fruit of true cooperation. One example is Airbus with a 30% share of the world civil aviation market; another are the helicopters with a 40% share of world sales through the EUROCOPTER company. 70% of AEROSPATIALE's turnover is realized from programs which involve cooperation with other aerospace partners.

Within the context of a partnership built upon free exchange of information, methodology, technology and human resources, the US aerospace industry plays a leading role in a number of AEROSPATIALE aeronautical programs.

AEROSPATIALE

For More Information Circle No. 595

AEROSPATIALE INC. 1101 Fifteenth Street N. W. Washington, D. C. 20005-3099 - Telephone (202) 293-0650 - Telecopier (202) 429-0638

Alcatel Space, Europe's Satellite Communications Specialist

An Alcatel Espace engineer checks microwave sources of the Eutelsat 2 communications satellite's main antenna during RF tests under a radome in Alcatel's Toulouse facility.

The Alcatel Space Division of the powerful multinational group Alcatel NV is itself a true international venture controlling eight European subsidiaries: Alcatel Espace (France), Alcatel SEL (Germany), Alcatel Kirk (Denmark), Alcatel Espacio (Spain), AME Space (Norway), Telettra (Italy), Alcatel Bell and ETCA (Belgium). Last year, it achieved global sales exceeding $500 million with a workforce of 2100.

Alcatel Space Division president Jean-Claude Husson also manages Alcatel Espace, the largest unit with facilities in Paris and Toulouse. Last year, its staff of 1300 achieved sales of approximately $450 million.

Europe's leading figure in the spaceborne communications business, Alcatel Espace has been involved in some 50 satellites now in orbit and is working on about 20 more. It is known as a manufacturer of electronic equipment, subsystems, and complete payloads for communications, observation, and scientific satellites. The company also manages complete communications satellite systems, including space and ground segments. Ground stations are provided by its relative, Alcatel Telspace, Europe's largest manufacturer of standard ground stations and VSATs.

Husson's team demonstrated its ability to manage complex communications satellite systems when it installed the new Telecom/Syracuse 2 French civil/military satellite system. It was developed under the largest contract (more than $1 billion) ever received by the Space Division. The system, the first of three Telecom 2s, entered operational service earlier this year following the successful launch by Ariane.

In 1992, Alcatel Espace celebrates other important achievements with the first flights of two advanced technologies: the Poseidon radar-altimeter, a component of the Topex oceanographic satellite that will be launched by Ariane for NASA; and the IOC (Inter-Orbital Communications) radio link to be tested by ESA's shuttle-borne Eureca platform.

Poseidon is the first spaceborne radar fully developed in France, under a $25 million contract from CNES. The solid-state radar-altimeter will accurately measure the satellite's altitude above the oceans, enabling global determination of sea heights, currents, and swells. Husson expects further sales of Poseidon for civil and military satellites; Poseidon is part of a GE proposal for the US Navy Geosat altimetry satellite project, and it is envisioned for NASA's EOS polar platform.

Capitalizing on Poseidon as well as the company's experience in radar data processing for ERS, Alcatel Espace is developing critical technologies for advanced SAR, including an S-band radar for the European Polar Platform and an X-band radar for CNES' Radar 2000 project. IOC will soon be tested between the low-flying Eureca platform and the Olympus 1 geostationary satellite. The S-band link will be the first intersatellite experiment conducted by Europe. Alcatel Espace is working on another S-band link for Spot 4 and Artemis, and an advanced intersatellite link in Ka-band with Alcatel Bell. A 20-30 GHz, high-data-rate (500 MBits) link is envisioned for future European (and possibly foreign) Data-Relay Satellites.

The French company has teamed with Alenia Spazio to build Artemis, the precursor of the European Data-Relay Satellite. Alcatel and Alenia have formed with Aerospatiale the "Euro-Alliance" to share communications satellite business among themselves and their American partner, Space Systems/Loral. The team is building a series of seven Intelsat 7 satellites. Alcatel Espace is providing the complete communications module for the Intelsat 7s. It did the same for Turkish satellites and also built Turksat ground segments under a $100 million contract.

Moreover, Alcatel Espace is producing for CNES its new S-band satellite control station to be installed next year on the Kerguelen Islands (in the Indian ocean) for monitoring French civil and military satellites.

Space is our World.

Space is open in theory to all mankind, but in practice only the dedicated few have access, the professionals of Space.
The haphazard has no place in this universe where Quality is the absolute criterion.
In fact, Space is an ever-demanding world : greater expertise to master the technologies, broader innovation in response to new challenges, sharper vision in anticipating the future. Day after day, Alcatel Espace provides tangible proof of its natural talent.

From the communication electronics of Ulysses to the Poseidon radar altimeter carried by Topex, from the synthetic-aperture radar of ERS 1 to the prime responsability and payload supply of Telecom 2, from the equipments for the Intelsat VI & VII programs to the supply of space and ground Syracuse I & II military telecom systems... Alcatel Espace thrives on success and technological 'firsts' with passion.

Space is our World, naturally.

ALCATEL
ESPACE

11, avenue Dubonnet . 92 407 Courbevoie Cedex, France
Tél. : (33.1) 49 04 47 10 . Fax. : (33.1) 49 04 47 98

Dassault's Man-In-Space Expertise

Dassault's Space Division has a leading role in the development and testing of the Hermes spaceplane.

Dassault's space activities and goals have thus far been focused on manned spaceflight. The company has been involved in the study and development of the Hermes spaceplane and related man-machine interfaces, orbital operations and controls, and crew safety and rescue systems, including ejection seats and special space suits for intra- and extra-vehicular activities.

Well known as a combat aircraft designer and manufacturer, Dassault entered the space arena eight years ago when it was named prime delegate contractor for the Hermes spaceplane, with responsibility for the craft's aeronautics. The company, managed by Serge Dassault, has contributed to basic design choices involving shape definition, thermal protection, hot structures, and safeguard subsystems.

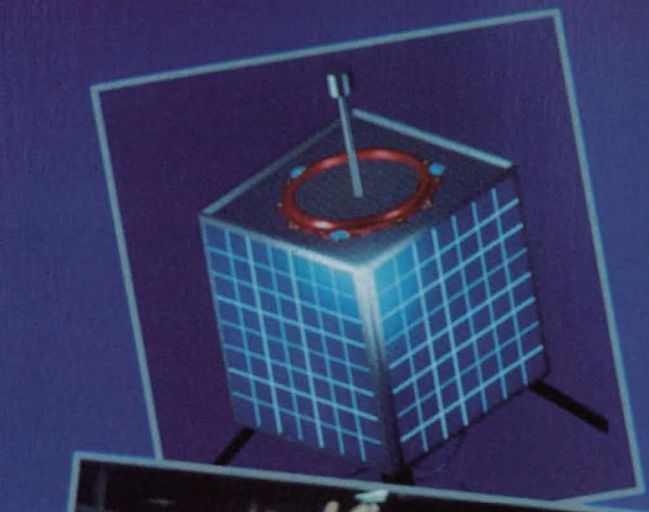
Within the new Euro-Hermespace consortium, Dassault Aviation is sharing the overall industrial responsibility and technical management of the program. In particular, Euro-Hermespace has given Dassault several major and critical tasks including aerodynamic design and shape definition, aerothermodynamics and reentry trajectories, aeromechanics architecture, thermal protection and hot structures, navigation and control, flight control and reentry software, crew safety, subsonic flight tests, and orbital flight tracking. It is also studying special aircraft for Hermes crew training and spaceplane transportation and subsonic tests.

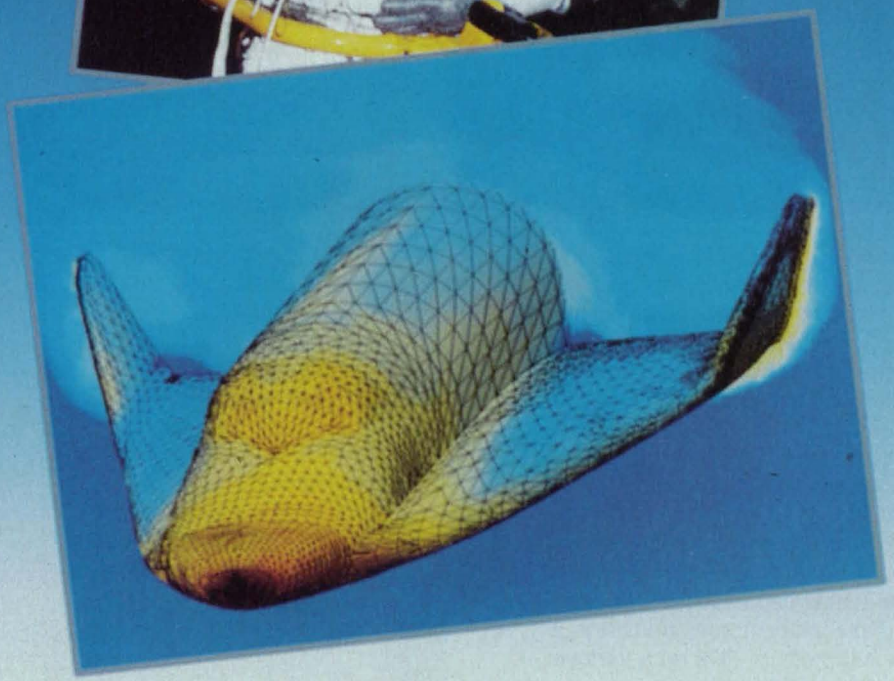
According to Jean-Gerard Roussel, head of Dassault's Space Division, most of these tasks are being or will be achieved through a broad range of European and international cooperations needed to meet the project's many technological challenges. For example, the French team recently achieved a world "first" when it successfully built winglets made of new ceramic composites (C-SiC). The lightweight (60 kg) critical structure is designed to sustain heavy loads up to 21 tons under high thermal flux of 330 kw.

Dassault's expertise in man-machine, crew environment interface, and artificial intelligence techniques learned from supersonic aircraft work could be widely applied to space vehicles. CCV (Configuration-Controlled Vehicle) flight techniques developed for the Rafale interceptor, for example, are used extensively in the Hermes program to achieve extremely safe reentry, approach, and landing. The company also hopes to exploit its capabilities in other critical technologies such as pyrotechnic devices, nondestructive testing, and system studies for all types of space products and activities.

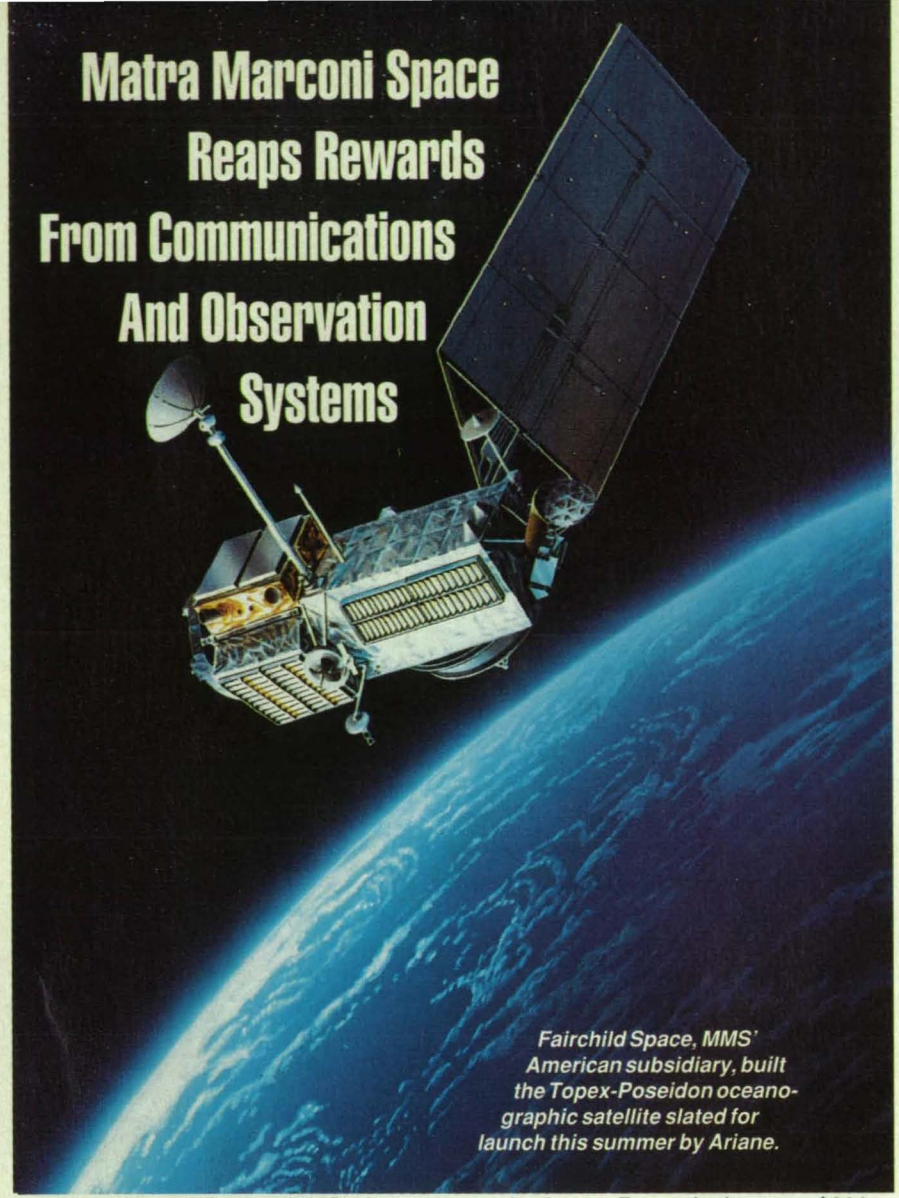
Jean-Gerard Roussel emphasizes the openness of the company to cooperative ventures with foreign partners. Hermes has fostered partnerships with a number of firms in Western Europe as well as new relationships with Soviet aerospace companies such as Energia and wind tunnel operators such as Molnya and TSNII. Dassault has already established a partnership with Zvezda, the Soviet specialist for crew safety equipment, to provide ejection seats and associated suits for Hermes pilots. Zvezda developed for the Mig-29 combat aircraft special ejection seats, a derivative of which is used on the Buran shuttle. This seat is the only one in the world qualified for safe ejection up to Mach 3 and a maximum altitude of 25 km. Dassault is also investigating possible cooperative ventures with U.S. firms and has initiated joint studies with Defense Systems Inc. of MacLean, Virginia.

Space: another way





Matra Marconi Space Reaps Rewards From Communications And Observation Systems



Fairchild Space, MMS' American subsidiary, built the Topex-Poseidon oceanographic satellite slated for launch this summer by Ariane.

Matra Marconi Space (MMS), the first integrated space company in Europe, was founded two years ago by merging the French firm Matra Espace with Marconi Space Systems of the United Kingdom. Counting Fairchild Space, the wholly-owned subsidiary of Matra Space and Defense, the company's workforce numbers 4500. Negotiations with BAE Space Systems and ANT, the space arm of the German Bosch group, could result in further growth. MMS chairman Claude Goumy expects the company to achieve a 5% net profit in 1992 on a turnover approaching $1 billion.

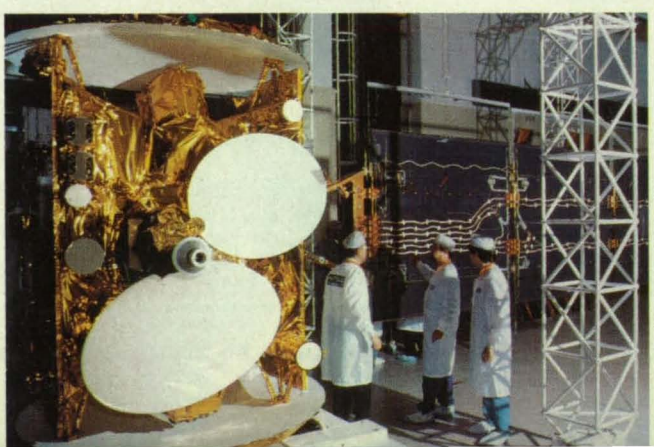
The group manages approximately 30 programs including the equipment bay for Ariane rockets and data management software and hardware for manned systems such as Columbus and Hermes. It is also developing the robotic remote manipulator for Hermes. But its main business is building satellites for remote sensing, communications, and science. Recently, it won a $200 million contract to build Soho, a solar heliosphere explorer to be launched by an Atlas ELV in 1993. Its American subsidiary, Fairchild Space, built the Topex oceanographic satellite planned for launch this summer by Ariane in a cooperative venture with NASA

Earth observation satellites account for 47% of the company's sales. Spot 3 is ready for launch and the company is preparing Spot 4, an upgraded version of the French satellite equipped with advanced magnetic tape recorders, an additional infrared channel, and new experimental payloads. Spot 4 will be the first European spacecraft to test an intersatellite laser link called Silex, developed by MMS under an ESA contract worth $110 million. Using 25-cm-aperture telescopes and 60-mw laser diodes, the optical link will be beamed between Spot 4 in low-Earth orbit and the Artemis satellite (planned for a 1995 launch) in geostationary orbit.

The French-British group is providing the platform and/or instruments for new European Earth observation satellites such as Meteosats, ERS 1 and 2, and the European Polar Platform. Its communications satellite business is also healthy, with construction taking place in Toulouse and Portsmouth. After delivering two French Telecom 2 satellites built in partnership with Alcatel Espace, MMS is now integrating two Hispasat 2s to be launched for Spain in 1992-93. The satellites are very similar in design and complexity, featuring an incredible density of equipment on their Eurostar platforms.

MMS is creating the payloads for several communications satellites, including Eutelsat 2, Inmarsat 3, Skynet 4, and NATO 4. Moreover, it is partnering with British Aerospace to build the Orion satellite and with GE Astro Space to build Koreasat.

A less-publicized activity of the French-British group is very-small-aperture terminals(VSATs). Matra Marconi Space has manufactured more than 2000 VSATs, 1600 of which are installed in 100 countries worldwide for approximately 600 customers. It is currently developing and testing two-way small terminals in a cooperative venture with SkyData of the U.S.



MMS developed France's new Telecom 2 civil and military communications satellite, shown here during final tests with its solar panels fully deployed.

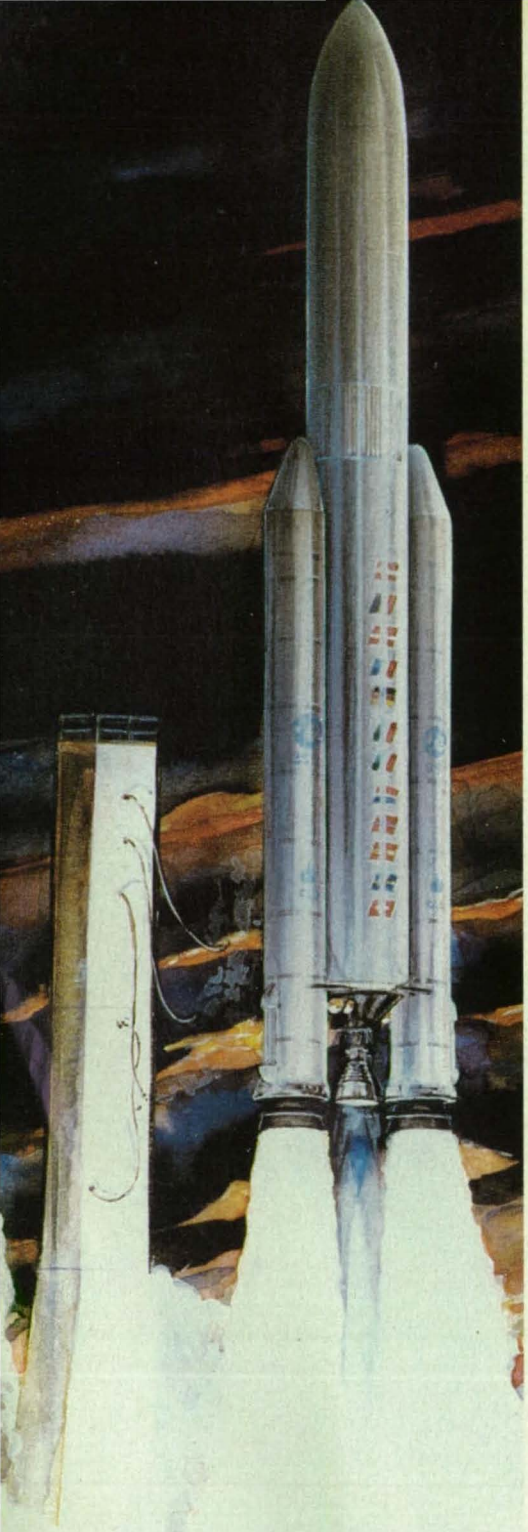
EuroStar, our "satellite line", rolls out its latest products: Inmarsat 2, Telecom 2.

Our EuroStar platform is so modular and adaptable that it enables a production line approach to manufacturing satellites, without compromising or restricting payload performance. That means the latest generations of satellites now benefit from quicker development and assured quality. And all at a lower cost than ever before. Developed jointly by Matra Marconi Space and British Aerospace, EuroStar meets the needs of the widest range of communications missions. EuroStar's success in orbit speaks for itself: three Inmarsat 2s and the first Telecom 2 satellite. For more information, call Matra Marconi Space UK: 44 705 66 49 66 - France: 33 (1) 34 88 30 00

MATRA MARCONI SPACE

For More Information Circle No. 590

SNPE Propels Europe Into Space



SNPE is developing the two huge solid boosters that will propel the Ariane 5 rocket. This artist's conception of an Ariane 5 liftoff will become reality in late 1995.

SNPE's involvement in space propulsion dates back nearly ten years, to when the French firm—known as a manufacturer of rocket motors for ballistic and tactical missiles—began producing liquid and solid propellants for the Ariane launch vehicle in Toulouse.

It started with the production of UDMH (unsymetrical dymethyl hydrazine) in 1983. The liquid fuel, mixed with nitrogen peroxide, still propels most rockets, including Ariane. The current production rate for Ariane 4 first and second stages is about 900 tons per year.

The company also produces MMH (monomethyl hydrazine) for satellite and rocket engines. The fuel will be used in anhydric form (with a purity exceeding 99%) on the third stage of Ariane 5. A pilot facility opened last year in Toulouse is sized to produce 50 tons of MMH annually.

Yet another SNPE product is ammonium perchlorate, the main component of European rockets, including the modest boosters of Ariane 4 and the huge solid motors of Ariane 5. The basic chemicals needed to make the white powder are well known, but the *savoir-faire* is to obtain a product with high purity and a perfectly controlled granulometry (particle-size distribution). The latter determines the energetic properties and combustion quality, which directly affect booster performance.

SNPE mass-produces ammonium perchlorate in Toulouse, then ships it to a new plant in French Guiana where the propellant is manufactured. The facility is managed and operated by Regulus, a joint company formed by SNPE and BPD. The ammonium perchlorate is mixed with other components, including aluminum, to make the final solid propellant that will produce the nearly 1200 tons of thrust needed to lift Ariane 5 skyward. The chemical is prepared in two 1800-gallon mixers bought in the United States.

SNPE is developing a new "clean" solid propellant for future launchers, possibly an advanced pollution-free version of Ariane 5. Only three countries—France, Japan, and the U.S.—are investigating such low-pollution solid propellants, designed to protect the environment. The problem with existing solids, all based on ammonium perchlorate, is that they generate combustion pollutants including gases and particles. In particular, they eject large quantities of hydrochloric gas that can recombine with water in the atmosphere to produce local acid rain or interfere with chemical reactions and damage the ozone layer.

To deal with the problem, the French group decided it would be better to develop a new formula rather than modify the existing propellant, in order to maintain performance while reducing the pollutants. So SNPE reformulated the propellant to totally eliminate chlorine ingredients and use instead ammonium nitrate or nitramines as the oxidizer, while adding a new component: GAP (glycidyl azide polymer). This energetic polymer replaces the polybutadiene binder and compensates for any negative effects of the pollution-free formula. The "magic" chemical would allow the total elimination of hydrochloric acid while retaining AR5's desired performance characteristics.

A test-firing of a first-generation, low-pollution propellant is scheduled to take place this year at the SNPE facility near Bordeaux. It will use a propellant grain of about 200 kg. Then, within two to three years, plans call for the test of a totally clean propellant made of GAP. SNPE has already signed an exclusive licensing agreement with the Rocketdyne division of Rockwell International to produce and market GAP in Europe.

TACTICAL PROPULSION.
LET US GIVE YOUR PLANS OUR CREATIVE POWER.

Tout arrive par les idées" - F.R. de Châteaubriand.

Let us together make your dreams come true. We shall develop both pioneering and effective solutions to meet your requirements in the best way. Our expertise in the fields of solid propellant, grain and rocket motor design, and industrial process will significantly help your weapon systems to become more effective and more competitive. Of course we shall also meet your stringent demands related to S^3R and to large scale production. Our references : Ac 3g, Air to ground rockets, Ans, Apilas, Asmp, Aster, As 30 laser, Crotale, Durandal, Eryx, Exocet, Hawk, Hot, Masurca, Mica, Super 530 D, Milan, Mistral, Mlrs*, Roland, Shahine, S30. Call on us :*

SNPE Défense Espace 12, quai Henri IV 75181 Paris cedex 04 Phone (33) 1.48.04.68.31 Fax (33) 1.48.04.66.14.

** Under license.* *S^3R : Smokelessness, Safety, Survivability and Reliability.*

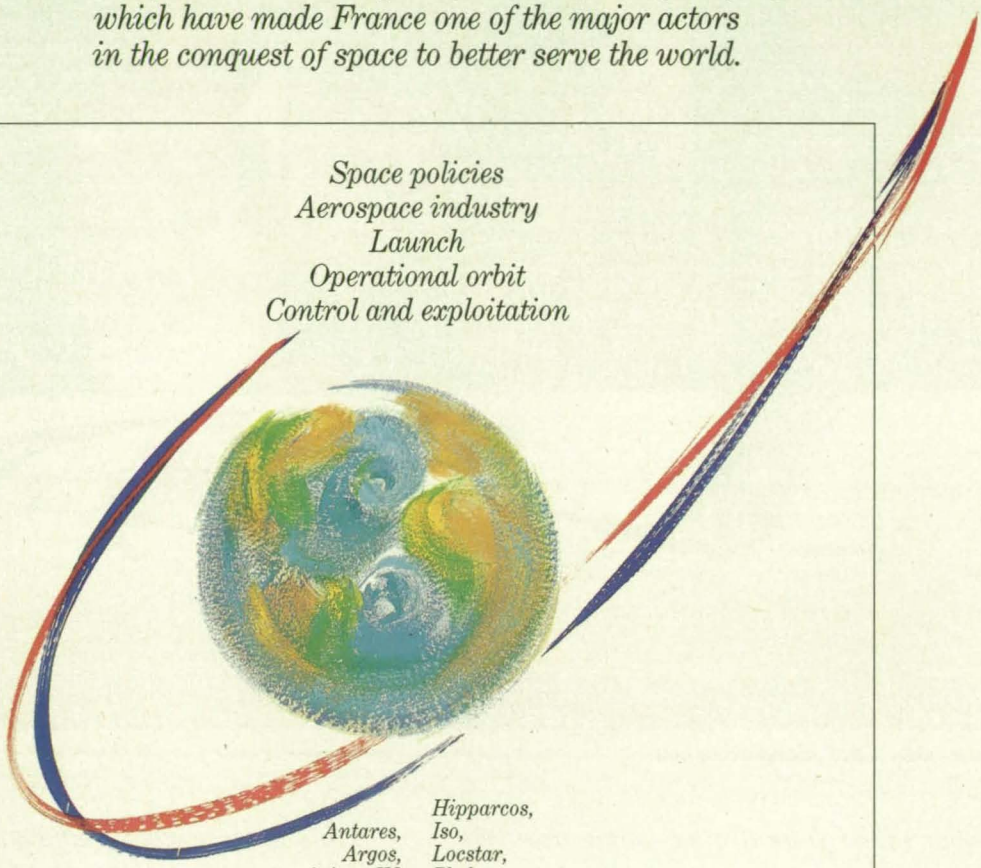
SNPE
DEFENSE ESPACE
MASTERS OF MATTER

For More Information Circle No. 594

THANKS AND CONGRATULATIONS!

Congratulations to all the scientists, engineers and companies who have cooperated in the implementation of the space programs which have made France one of the major actors in the conquest of space to better serve the world.

Space policies
Aerospace industry
Launch
Operational orbit
Control and exploitation



Antares,	*Hipparcos,*
Argos,	*Iso,*
Ariane IV,	*Locstar,*
Ariane V,	*Phobos,*
Columbus,	*Sigma,*
Cospas/Sarsat,	*Spot,*
Doris,	*TDF,*
Gamma,	*Telecom,*
Helios,	*Tele-x,*
Hermes,	*Topex-Poseidon,*
	Vega,...

cnes

WE OPEN UP SPACE

For More Information Circle No. 345

DARA Manages Germany's Space Programs

DARA helped develop ERS-1, the first European radar observation satellite, which will monitor coastal zones, ocean processes, and polar ice levels.

DARA (Deutsche Agentur für Raumfahrt-Angelegenheiten) GmbH, the German space agency, was founded just three years ago. Managed by Dr. Wolfgang Wild, DARA has directorates for space exploration, infrastructure, and administration, headed, respectively, by Prof. Heinz Stoewer, Klaus Berge, and Dr. Wolfgang Grillo. The agency's total staff is about 300.

DARA manages 500 projects and studies in 50 institutes and companies in the unified Germany. Earth observation is an important activity in the German space program, enabling the gathering of data concerning the global climate and environment. DARA is especially interested in space remote sensing to study and protect the environment, detect and exploit natural resources, and develop advanced technologies for future projects.

Germany recently achieved a breakthrough in astrophysics with Rosat's complete scanning of the sky, which will provide detailed data about x-ray sources. It will register another scientific achievement this year when the space shuttle flies the Eureca platform built in Germany for ESA.

DARA is making strides in the area of manned spaceflight. German astronauts will fly on Mir and the space shuttle in 1992, and again on the shuttle in early 1993 for the German Spacelab mission D2. This will prepare for utilization of the Columbus space station laboratory, developed under German leadership in cooperation with Italy.

German industry builds Ariane upper stages and the Vulcain engine, the largest European cryogenic engine, which will generate 100 tons of thrust for Ariane 5. Germany also participates in the Hermes program, while conducting preliminary studies of an advanced two-stage-to-orbit vehicle called Sanger that may fly in the early 21st century.

OHB-System, The German Microgravity Specialist

OHB-System is a small but skilled high-tech company with a staff of 90. Its R&D activities are focused on developing space hardware and conducting microgravity experiments with lightsats, recoverable capsules, sounding rockets, drop-towers, or parabolic flights for German and foreign users.

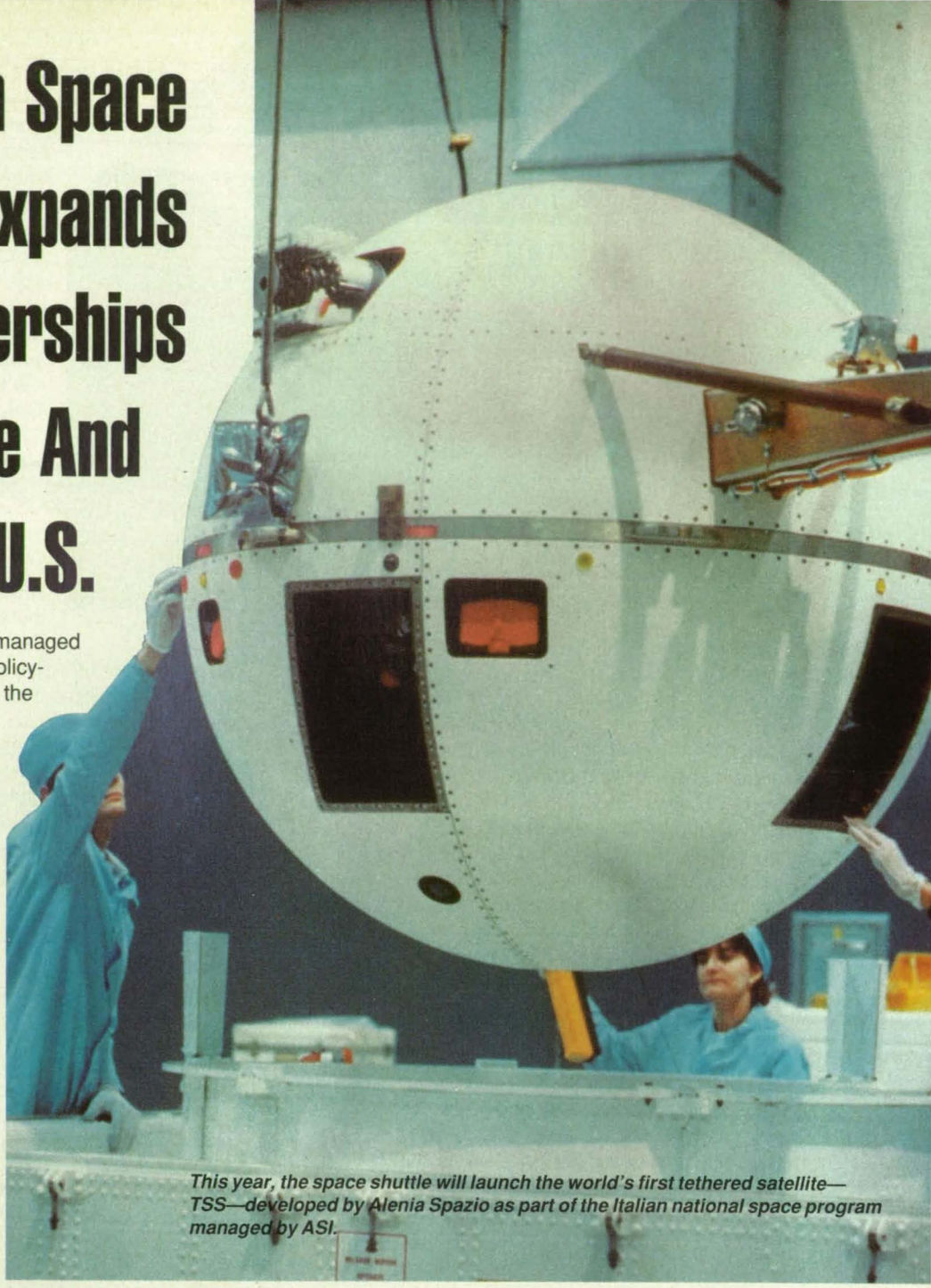
The company has developed centrifuges for microgravity experiments on the Spacelab D2 mission scheduled for early 1993. It built another centrifuge for the Nizemi experiment on Spacelab IML-2. The team led by Dr. Manfred Fuchs is now investigating an Anthrolab facility for Columbus.

The Bremen company is also developing biomedical equipment for blood and urine monitoring and other physiological tests to be made by a German astronaut during the Mir 92 mission organized last March by DARA.

Since 1987, OHB has participated in about 800 parabolic flights on NASA's KC-135 aircraft and CNES' Zero-G Caravelle (operated by Novespace) to prepare for Spacelab and Columbus microgravity missions. It operates on its own the Mikroba balloon-borne recoverable capsule, which is dropped from an altitude of 40 km. It is also considering the use of rockets to launch recoverable capsules such as Carina (Alenia), Topas (OHB), Express (DARA), and Aroc (CNES).

OHB provided the original design concept for Hermes' crew safety capsule, called Hercules, and for a shuttle aerodynamic test model. The latter, dubbed Falke, is a 7-meter carbon-fiber flight model first tested in 1990. OHB also develops payload and sensor elements for ESA's Polar Platform and builds lightsats such as Bremsat and Safir for environmental research and monitoring, under contracts from DARA, ZARM, and BmFT.

Italian Space Agency Expands Partnerships In Europe And The U.S.



This year, the space shuttle will launch the world's first tethered satellite—TSS—developed by Alenia Spazio as part of the Italian national space program managed by ASI.

Italy's space program is managed and monitored by a single policy-making and executive body: the Agenzia Spaziale Italiana (ASI), or Italian space agency. ASI is chaired by Prof. Luciano Guerriero, who is assisted by Prof. Carlo Buongiorno, director general of the agency.

ASI's budget will increase from $645 million this year to $725 million in 1994, as part of a five-year plan approved by the Italian government that allocates about $5 billion to space projects through 1995. This is split equally between space programs managed by ASI and European space programs managed by ESA.

Today, after ten years of growing resources and space capabilities, Italy is the third largest member of ESA. It provides about 18% of ESA's funding, thanks to a tenfold increase in Italy's space spending since 1980. This unmatched growth has allowed Italy to take significant shares in key European space programs including Hermes (12.5%), Ariane 5 (15%), Columbus (25%), and DRS (45%).

Italy's fast growth has enabled it to expand its cooperative ventures with ESA and NASA. Cooperation with the United States is nothing new, as Italy's first experimental communications satellite—Sirlo 1—was launched by a Delta rocket in 1977. Later, Italy launched small NASA scout rockets from the Italian offshore launching platform anchored near the coast of Kenya.

In 1992, cooperation between Italy and the United States will receive a spectacular boost with the flight of two Italian research satellites —TSS-1 and LAGEOS 2—built by ASI and launched by NASA.

The Tethered Satellite System (TSS) was built by Alenia Spazio using a concept invented by the late professor Giuseppe Columbo. This fascinating concept of tethering a satellite to its launch platform in space allows many completely new research applications. The satellite, connected to the end of the tether, will be deployed from the shuttle cargo bay and will explore space either downwards or upwards from the shuttle at a maximum distance of 100 km. It will then be retrieved using the tether system.

The tether allows such amazing applications as power generation or "space lift." During its first and second flights, TSS will investigate the feasability of producing electricity in space, for use on board future space stations or interplanetary probes, as well as thrust energy for moving payloads to and from orbital stations.

TSS-1 is planned for launch by the shuttle Atlantis this July. It will be deployed by Franco Malerba, the first Italian astronaut, trained as a shuttle payload specialist by NASA. The deployment and retrieval will be done

from a special platform developed by Martin Marietta Corp. of the U.S. The satellite will be linked to the platform in the shuttle cargo bay by a tiny cable made of two copper wires wrapped in Kevlar fiber. It will be deployed up to 20 km upwards from shuttle orbit (about 300 km). In space, the conductive wire will cut through the Earth's magnetic fields and generate electricity with a voltage that might reach 5 kv.

A second flight of this unique satellite is planned two years later using a much longer tether for deployment up to 100 km. This time, the TSS will be deployed down towards the Earth, allowing the spacecraft to move "in situ" to study the upper atmosphere in regions that usually cannot be reached by satellites. It will also be spun to generate a centrifugal force that will produce artificial gravity, useful for manned spacecraft during long-duration interplanetary flights such as a manned Mars mission.

The next Italian satellite to be launched by the shuttle is LAGEOS 2, a cooperative Italio-U.S. mission to study tectonic motion using lasers, built by Alenia Spazio under contract to ASI. Alenia will also supply the IRIS upper stage that will place LAGEOS 2 in operational orbit this fall.

Developed in cooperation with BPD, the IRIS may be used as an upper stage for the proposed Scout 2 solid rocket that would launch into low-Earth orbit small satellites weighing up to 700 kg. Further, ASI has discussed with China the possible use of the IRIS on LM2.

ASI-NASA cooperation has been enriched this year by new agreements. The two agencies recently signed a memorandum of understanding for the design and manufacture in Italy of two logistics modules that will be used to transport and provide support equipment and facilities to the international crews of space station Freedom. These Mini-Pressurized Logistics Modules are slated for launch in 1997.

Another agreement with NASA is in the definition stage—the Cassini interplanetary mission to Saturn, also scheduled for departure in 1997. Italy will be in charge of providing some essential elements of the deep-space probe, including the radio link that will allow the spacecraft to send its data billions of miles back to Earth.

Next year, the shuttle will fly SAR-X, a high-resolution X-band radar observation system for all-weather observation of the ground. SAR-X was developed by ASI in cooperation with DARA of Germany. The system will fly with the American SIR-C radar.

Remote sensing data from the X-band radar will be processed and archived at a ground station (PAF-I) built by ASI at Matera in southern Italy. Operated by Telespazio, the station is already processing data from the first European radar observation satellite, ERS-1.

In March, ESA and ASI signed a formal agreement making the Matera facility the Italian national data processing and archiving center for the exploitation of information captured by ERS-1 and then, when it is introduced in 1994, ERS-2. The agreement—signed by Jean-Marie Luton, ESA director general, and Prof. Luciano Guerriero, chairman of ASI—covers an initial period of ten years and allows the PAF-I center to collect, process, and deliver ERS data acquired from ground stations in Fucino (Italy) and Maspalomas (Spain) concerning the entire Mediterranean Basin. The PAF-I will use innovative technologies developed by Telespazio and ELSAG.

In cooperation with the Netherlands, Italy has developed SAX, an advanced x-ray observatory built by Alenia Spazio for launch by an Atlas rocket in 1994. That same year, Italy plans to launch Italsat F2, a follow-on to the Italsat F1 advanced communications satellite built and orbited by Italy last year. Italsat F1 is the first European satellite to work at upper frequencies of 20-30 GHz. This program has not only served Italy's domestic needs but has allowed it to become the lead country for developing—under Alenia Spazio's prime-contractorship—new European communications satellites, including the experimental Artemis spacecraft and the Data-Relay Satellites.

The LAGEOS 2 Italian geodetic satellite, scheduled for launch by the space shuttle this fall, will be placed in its final orbit by the IRIS Italian solid upper stage.

Alenia Spazio, The Leading Italian Space Group In Europe

Alenia is the main manufacturer (outside the U.S.) of pressurized modules for manned laboratories such as Spacehab (shown here), space station Freedom, and the European Columbus lab.

Alenia Spazio was founded last year by merging the Aeritalia Space Division with Selenia Spazio, and regrouping around smaller but skilled space teams such as Laben, Proel Tecnologie, Space Software Italia, and Space Controls Alenia Honeywell, formed with Honeywell Inc. of the U.S. This space task force has about 2700 highly-qualified personnel generating sales of $430 million, or 10% of the Alenia group's 1991 total.

The new Italian space giant, headed by Andrea Pucci and chaired by Prof. Ernesto Vallerani, now represents about 70% of the nation's space capability. It has expertise in managing, developing, and manufacturing complete systems and equipment for science, communications, and remote sensing, as well as manned systems for national, bilateral, or international programs such as Ariane, Hermes, Columbus, and DRS.

Alenia Spazio is the European specialist for shuttle-borne pressurized modules. Capitalizing on Spacelab, the company is now building similar or smaller modules for manned orbital facilities such as Spacehab and Columbus. ESA has given it responsibility for the overall design, development, and integration of the Attached Pressurized Module (APM), one of the four permanent manned modules of the international space station Freedom and the first element of Europe's Columbus system that eventually will involve a Man-Tended Free-Flier (MTFF). The Italian firm is also building two small logistics modules to support Freedom in 1997 and may provide a life sciences module equipped with a 2.5-meter centrifuge in 1999, as part of a deal between ASI and NASA.

In a separate and private venture with Spacehab Inc., Alenia Spazio is producing other small pressurized modules under subcontract to McDonnell Douglas. The first of these manned orbital labs was delivered last January to the U.S. for flight aboard the shuttle in 1993. Vallerani estimates that Alenia Spazio's pressurized modules business now represents about $400 million.

The Italian firm is a leader in the communications satellite business. It participates in major foreign programs such as Arabsat, Eutelsat, and Intelsat, and is prime for Italsat, the first satellite in Europe to operate at frequencies of 20-30 GHz. Italsat F1 is operational since last April and Italsat F2 is to be delivered in August 1994.

For ESA, the team participated in the development (and then the rescue) of Olympus 1, the largest and heaviest communications satellite ever built in Europe. Alenia Spazio is currently prime contractor for the experimental Artemis communications satellite to be launched in 1995 and the $1 billion European Data-Relay Satellites (DRS) planned for 1998.

As a member of the Euro-Alliance (with Aerospatiale and Alcatel Espace), Alenia Spazio will have a share in building two N-Stars under the aegis of Space Systems/Loral for the Japanese company NTT.

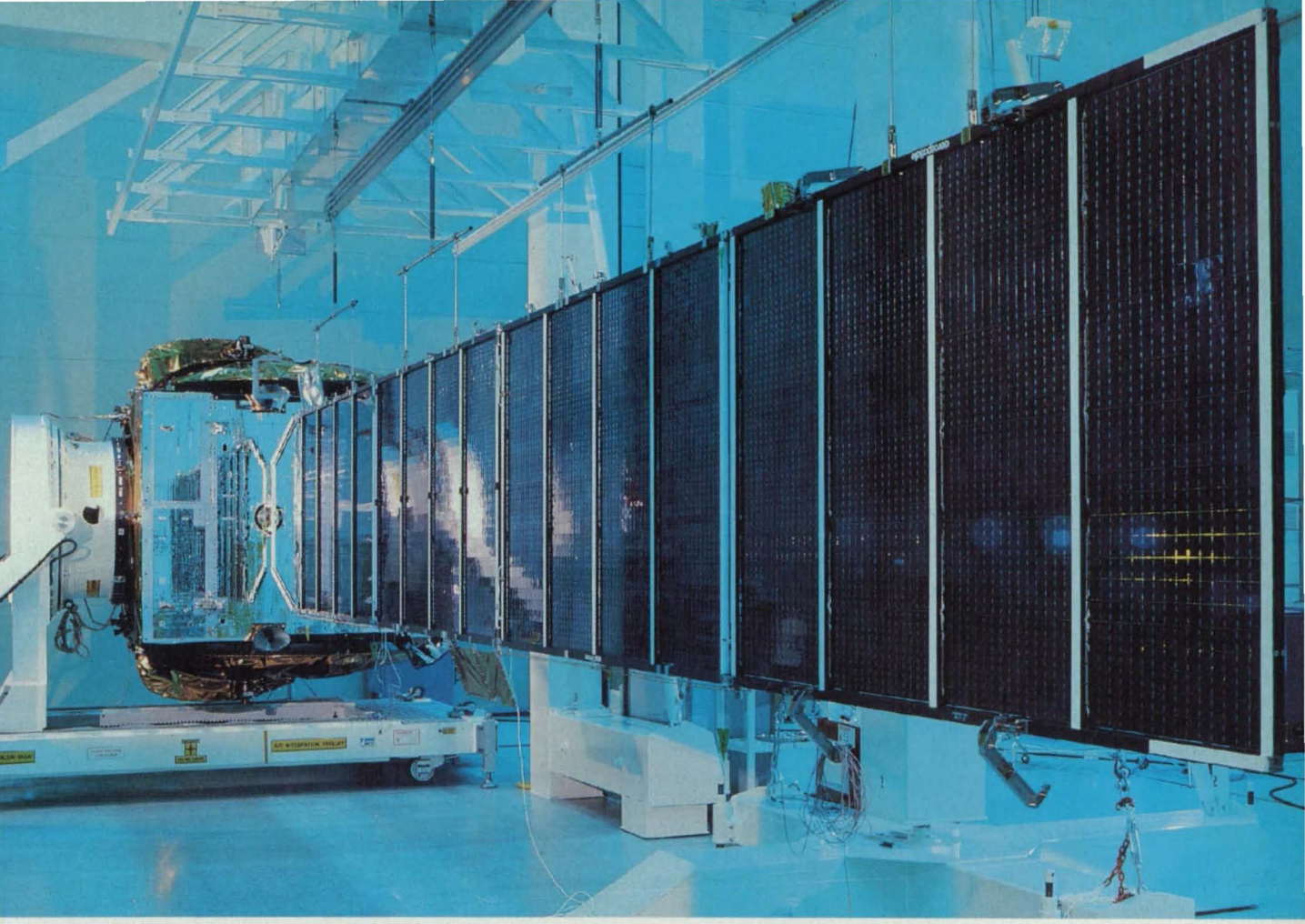
The company has installed 500 communications and control stations worldwide. It recently won a contract from South Korea to jointly develop with the local firm ETRI a communications link using advanced coding techniques.

Alenia Spazio installed the Argo emergency mobile communications system for the Italian Civil Protection ministry, and is now looking at the growing military space sector. It is prime for Italy's first military satellite system, Sicral, to be launched by Ariane in 1995. And it has a 14% share in the Helios military observation satellite system, with responsibility for building spacecraft parts and a complete data receiving and processing center in Italy.

The Alenia team is also familiar with microwave spaceborne sensors. It built radar-altimeters for the first European radar observation satellites: ERS-1, operating since last year, and ERS-2, to be launched in 1994. It is developing with Germany the shuttle-borne SAR-X synthetic aperture radar and, with the Netherlands, the SAX x-ray astronomy satellite, both planned for launch in 1993.

But 1992 will be the company's busiest year, according to Vallerani. Three pieces of Italian hardware—TSS, IRIS, and LAGEOS 2—will be launched by the shuttle in cooperative ventures with NASA. The Tethered Satellite System, a spherical body measuring 1.6 meters in diameter and weighing 500 kg, will be deployed from the shuttle in July by Franco Malerba, the first Italian astronaut.

Connected to a 20-km-long conductive tether made of copper and Kevlar, the TSS will study the electrodynamic environment and the feasibility of generating electricity in space. Then, this fall, LAGEOS 2 will be launched using the first Italian-made upper stage, IRIS. LAGEOS 2 is a 410-kg, 60-cm-diameter aluminum sphere covered with 426 laser reflectors to aid satellite tracking, providing increased accuracy in geodetic measurements.



TELECOMMUNICATION SATELLITES. OUR TECHNOLOGY SHINES AMONG THE STARS.

Alenia Spazio S.p.A., an Alenia company of the IRI FINMECCANICA GROUP, has been communicating in space for more than twenty years. Thanks to the advanced technologies and experience acquired, it is today a European leader in satellite telecommunications. A series of projects running from Sirio and Intelsat to Olympus and Italsat has been placed in space by Alenia Spazio, marking a continuous and extraordinary technological growth. And the successes obtained have brought the company to the position of prime contractor for a new generation of complex satellite systems such as Sarit, Artemis, DRS and Sicral.

Alenia

GRUPPO IRI FINMECCANICA

For More Information Circle No. 598

Telespazio, The Satellite Service Specialist

Telespazio is a specialist in satellite image processing. This picture of the Adriatic sea captured by Landsat 5 clearly shows water currents and pollution.

For 30 years, Telespazio has been the exclusive concessionaire for implementing and operating satellite communications systems in Italy. The IRI company, owned in equal parts by Stet, Italcable, and RAI (the Italian state broadcasting body), provides traffic capacity to national and foreign users via international satellite systems including Eutelsat, Intelsat, and Inmarsat.

Using the satellite capacities of Eutelsat and Intelsat, Telespazio promotes business-oriented, national applications for voice, video, and data transmission using very-small-aperture terminals (VSATs). Major networks have been installed for traffic control, social security, flight assistance, railways, and other applications. They include about 400 VSATs.

The company develops and manages "business television" satellite networks for voice or video conferences. Hundreds of conference rooms and hotels are equipped throughout Italy, Europe, and North Africa. Telespazio also promotes mobile stations.

It created and operates the largest satellite stations in Italy and Europe. Starting with the Fucino center near Rome, Telespazio expanded to Lario, near Lake Como, and Scanzano, in Sicily.

Managed by Dr. Raffaele Minicucci, the company has a staff of about 1000. It has provided operation and maintenance support for Intelsat and Comsat birds since 1968. Now, the Italian team routinely controls dozens of spacecraft for national or international communications. Recently, it contributed to the rescue-in-orbit of Olympus 1, ESA's largest communications satellite.

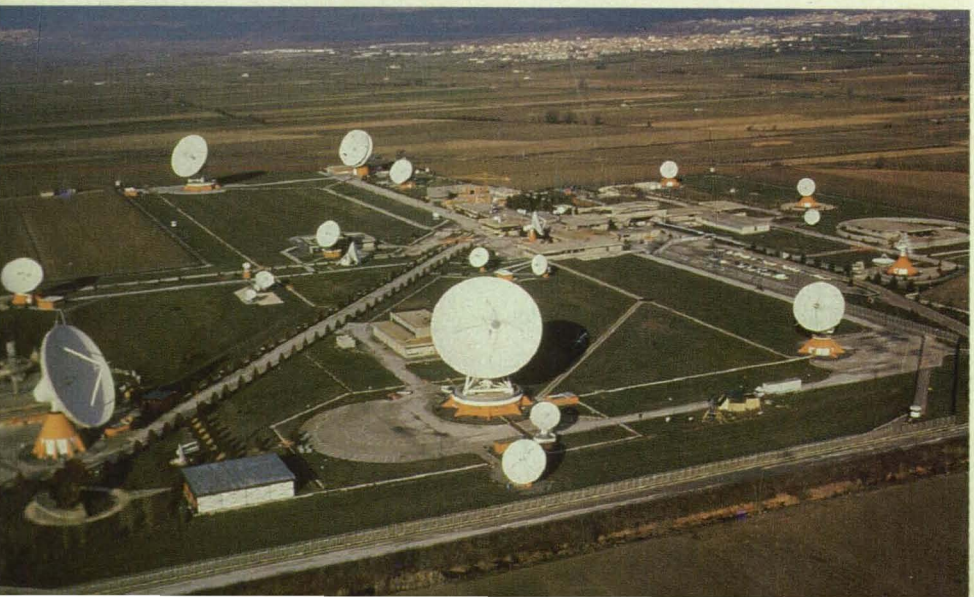
The team operates a control center for the Italian domestic satellite communications system (Italsat), ensuring centralized management of the satellite communications network including the ground traffic stations. It participates in Italsat propagation experiments and in networks supporting the European space infrastructure including Columbus, Hermes, the European Polar Platform, and Data-Relay Satellites.

An important Telespazio innovation is Argo, the emergency communications satellite system built on behalf of the Italian Civil Protection Dept. The land-mobile network includes small transportable stations, carried on trucks or helicopters, to quickly restore vital links with distressed areas. It can collect and relay seismic, hydrogeologic, and volcanic data. Telespazio also participates in the Sarsat-Cospas search and rescue satellite system, and promotes the Euteltracs radio positioning service in Italy.

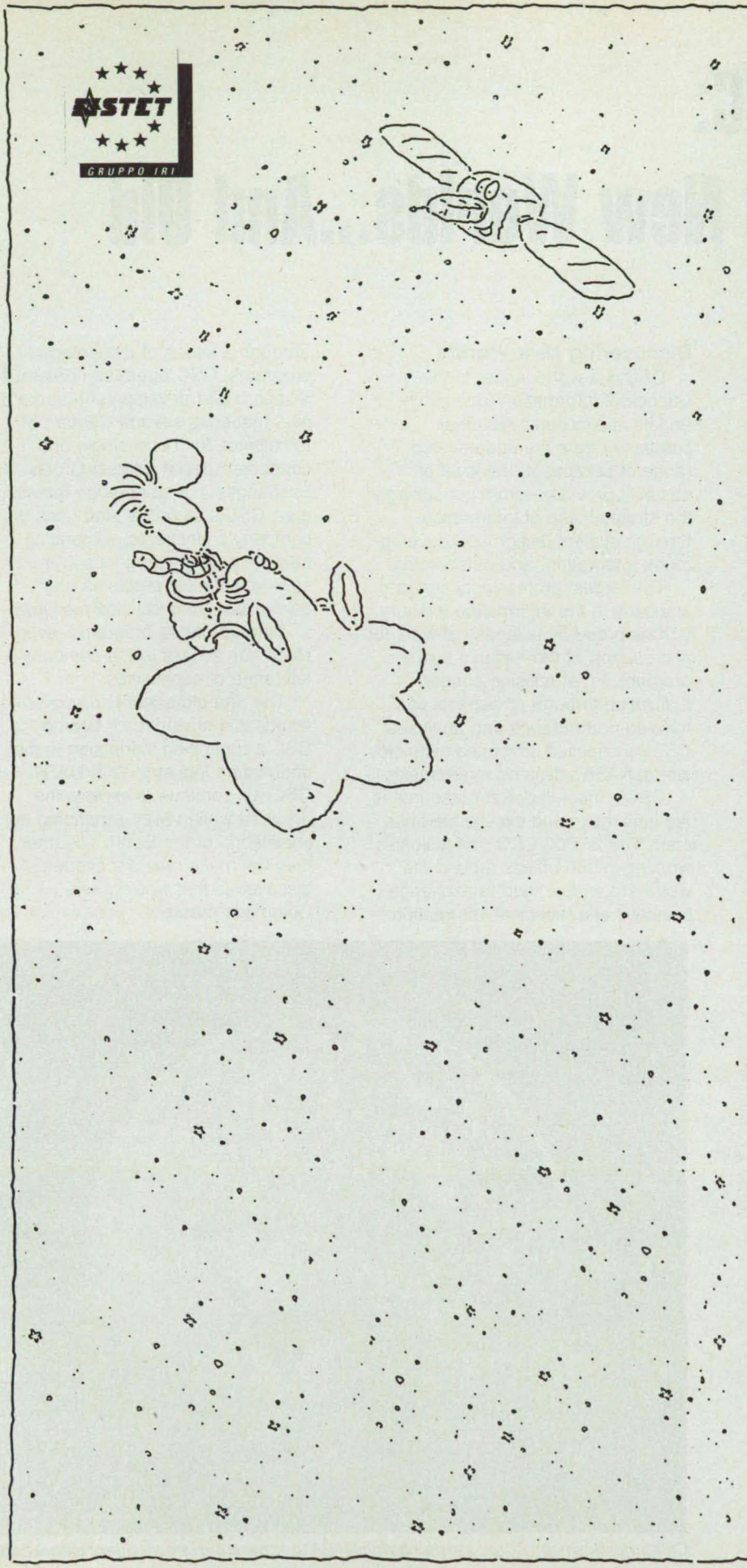
Minicucci's team is expert in Earth observation and environmental data processing and analysis. In Italy, it is both the contact point for experiments with Earthnet and the processing and distribution center for data acquired from remote-sensing satellites such as the American Landsat, French Spot, Japanese MOS, and European ERS-1 radar satellite.

Telespazio is engaged in major environmental satellite programs including the Mediterranean survery for coastal protection, the *Terra del Sud* information systems for agriculture in southern Italy, the *Telaer* airborne remote-sensing service, and *Progetto Coste* for classifying Italy's sea-coast pollution. Other environmental studies concern the Baltic Sea and Africa.

The firm recently signed several cooperative agreements with Soviet organizations, including Planeta and Agroresources, to develop sophisticated methods to improve environmental surveys and use remote-sensing data for agricultural monitoring in the former USSR.



In Fucino, near Rome, Telespazio operates the largest satellite communications Earth station, which is linked with national and international satellites including Intelsat and Inmarsat.



STET
GRUPPO IRI

Caro satellite, ma chi ti conosce?

Uomo: Caro satellite, sulla Terra si fa un gran parlare di te. Trasmissioni via satellite, telefonate via satellite, immagini della Terra dal satellite. Ma insomma, tu cosa fai veramente?"

Satellite: "Tanto per cominciare, caro amico, io ti dò una libertà di comunicare praticamente senza limiti. Qualsiasi azienda o ente, tramite me, può collegarsi con chi vuole, dove e quando vuole. E può ricevere e trasmettere dati, voce, immagini, testi a una velocità e a un livello di qualità altissimi. E senza interruzioni."

Uomo: "Sembra fantascienza. E poi?"

Satellite: "Poi ti dò la possibilità di capire meglio il tuo pianeta, e di proteggerlo. Con me, puoi vedere se in una foresta ci sono alberi malati, se una nave scarica petrolio in mare e come si muovono le alghe nell'Adriatico. Puoi prevedere il tempo e aiutare l'agricoltura. Puoi prevenire e combattere gli incendi, puoi ristabilire i collegamenti in zone colpite da calamità. Data la mia posizione, diventa tutto più semplice. Vado avanti?"

Uomo: "Beh, mi fai venire voglia di conoscerti meglio. Voglio sapere tutto di te."

Satellite: "Un modo c'è. Parlane con Telespazio. Lavoriamo insieme da trent'anni."

Uomo: "Bene, è stato un piacere. Ci rivediamo?"

Satellite: "Quando vuoi. Io sto sempre qui."

telespazio

La via al satellite.

NASA And CSC: Discovering New Worlds...And Old

The quest for discovery...for adventure...for exploration of the unknown...has driven man for centuries.

In 1492, when even scholars thought the world was flat, Columbus set sail. With his three small wooden ships, he pursued his dreams. And what he discovered—a new world—changed the course of history.

Five hundred years later, NASA and Computer Sciences Corporation (CSC) are proudly continuing this tradition of discovery. Through the use of manned and unmanned spacecraft, they are unlocking the secrets of the universe and of our home planet. Using advanced technologies Columbus never dreamed of, they are discovering new worlds above, while still learning about the old world—Earth—below.

Discovering Earth

The technologies that are part of the nation's space program are now being focused on projects to improve the environment on our fragile planet. NASA is participating in the government-wide Global Change Research Program that is helping to define the symptoms and diagnose the cause of the Earth's deteriorating environmental health.

Working shoulder-to-shoulder with NASA, CSC is preparing for this space exploration adventure. The company's quarter century of experience has resulted in numerous software and system methodologies that will pave the way for the efficient and effective development of new technologies for use in the exploration of Earth—from space.

At CSC's Center of Excellence for Space, Earth, and Life Sciences, leading scientists are able to carry out cutting-edge research. The center acts as a catalyst to combine scientific research with advanced technologies.

Discovering New Worlds

CSC is a world leader in the science of information technology and its applications. No other company offers the unparalleled range of services at the level of quality it provides—from consulting in the strategic use of information through system design and development, integration, and outsourcing.

The largest professional services company in the information industry, CSC is proud of its legacy of work for and support of the nation's space program. From mission conceptualization through all aspects of mission performance and analyses, CSC has applied advanced technologies to NASA's dynamic requirements.

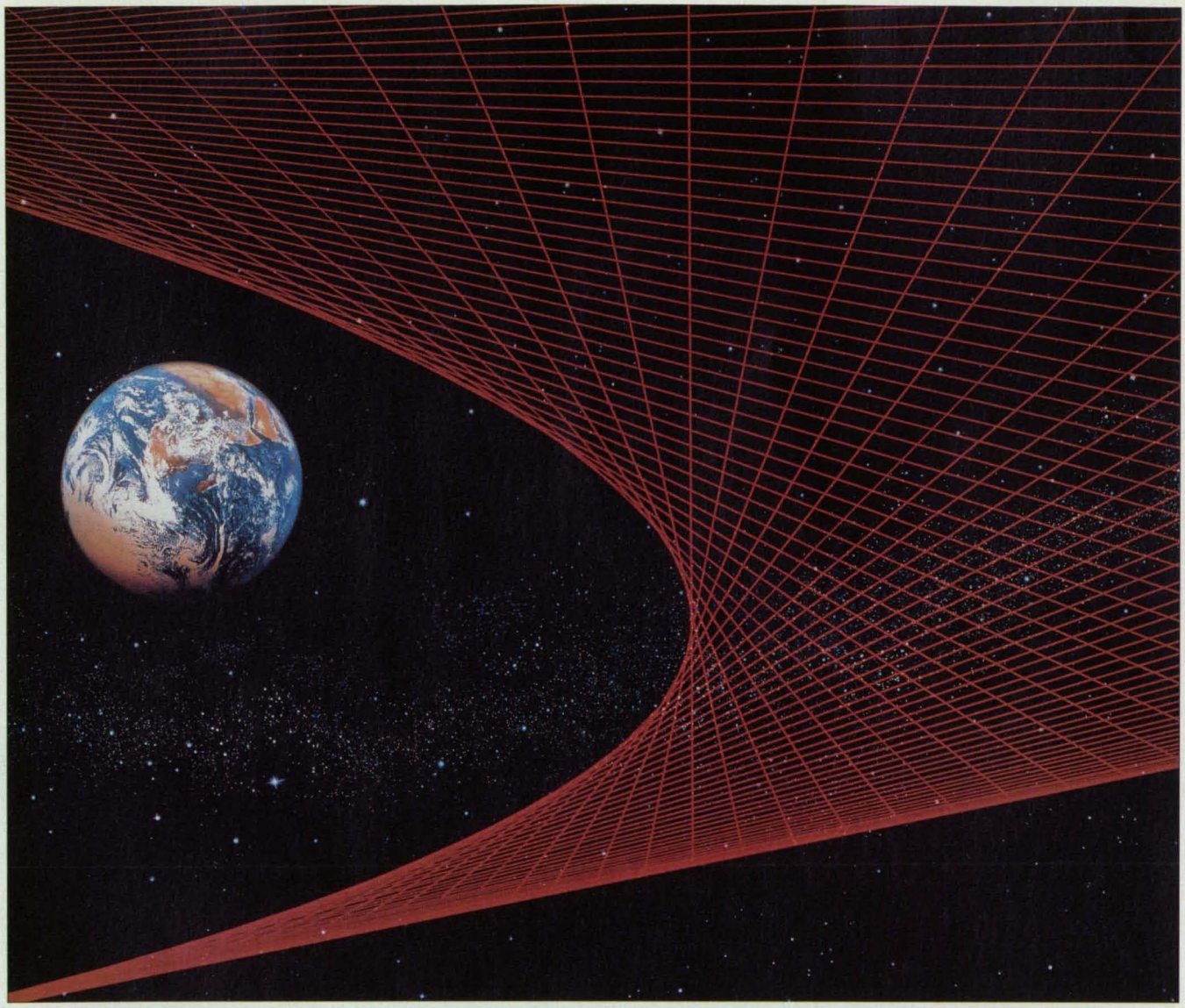
CSC's most important resource is the innovation and excellence of its staff. The 26,000 CSC professionals working in 300 offices around the world are encouraged to exchange scientific and technical information. Through a series of technology programs, CSC operates numerous research and development laboratories, manages several Centers of Excellence for Technology, and conducts Special Interest Group Exchanges in leading-edge technologies. CSC's technical staff uses the company's electronic referencing network as a clearinghouse for solving technical problems and quickly assessing technical resources.

Through these programs, every client has access to the company's full range of capabilities.

The age-old quest to discover new worlds is a driving force behind CSC's continuing leadership in the information industry. With NASA, CSC will continue to explore the universe while vastly expanding our knowledge of the Earth. Together, they will make new discoveries... discoveries that would make Columbus proud.

Computer Sciences Corp. is working with NASA to expand our knowledge of planet Earth.

The World Columbus Never Saw



CSC has been discovering new worlds with NASA for more than a quarter century.

From a small beginning at Goddard Space Flight Center in 1964 to our present role as a major contractor, CSC remains a proud part of the NASA team.

Supporting NASA Centers with broad ranging expertise...from systems integration, earth sciences, information processing and software development to ground-launch support and operations-maintenance. Applying CSC's specialized techniques and knowledge to flight dynamics, astronomy, space sciences, robotics and many other fields. Helping NASA—and America—discover new worlds.

CSC

Computer Sciences Corporation
System Sciences Division

4061 Powder Mill Road
Calverton, MD 20705
301.572.4900

For More Information Circle No. 518

Brunswick Defense Develops Advanced Space Products

Brunswick Defense and Brunswick Composites, both part of the Brunswick Technology Group, make a variety of technically-advanced, space-qualified products for the U.S. and European space programs.

Brunswick is the world's leading producer of propellant management devices, a supplier of a majority of filters on U.S. spacecraft, and a leader in fire suppression equipment and expandable robotic arms. Its WINTEC Aerospace Products Group supplies more than 95% of the liquid and gaseous filters on the space shuttle.

Both its propellant management devices, which help control propellant flow in zero-gravity, and its filters and screens depend on WINTEC's unique expertise in metals, welding, and design. All products are assembled and welded in its Class 10,000 clean room.

Its filters are available in wire mesh size ratings as fine as 20 micron abs. and are fabricated using proprietary Brunswick welding techniques and other technologies.

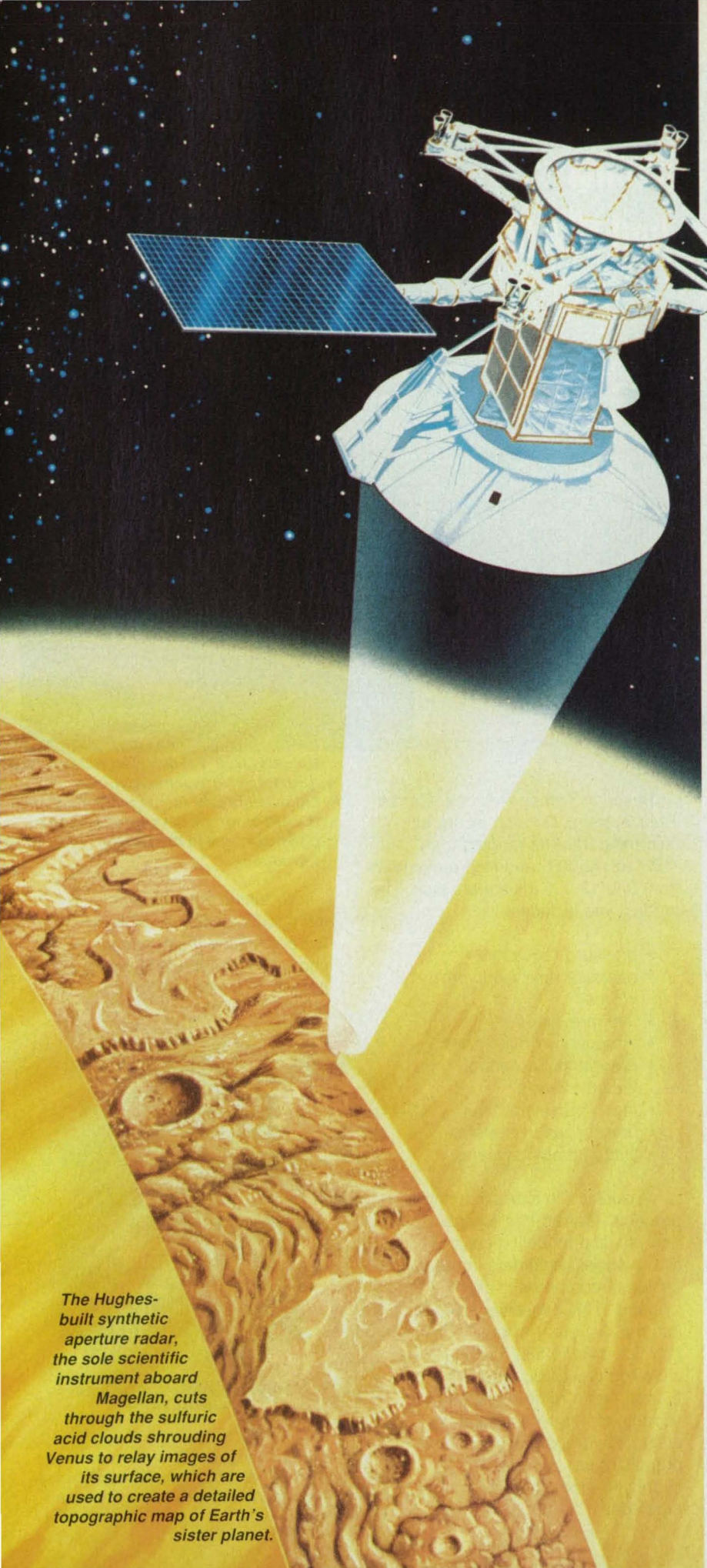
Brunswick continues to be a pioneer in designing strong, lightweight pressure vessels such as this one, for Intelsat VII. Its carbon-epoxy overwrap and plastically-operating aluminum liner reduce weight by 25% and costs by 30% compared to other technologies.

This includes a successful history of development and manufacture of welded stainless screen to titanium structures. Working with NASA in the early stages of the space program, WINTEC pioneered wire screen, contamination-free manufacturing processes.

More recent accomplishments include state-of-the-art advances in fine wire mesh titanium screen, 30 micron abs. and better, and a demonstrated ability to weld stainless wire mesh to aluminum.

Brunswick Composites is a leading producer of composite-wrapped, metal-lined pressure vessels for the space program—used for power sources, storage, and fuel management. It was the first to produce a man-rated, composite-wrapped space pressure vessel, for the Skylab program. It is also the leading non-propellant manufacturer of rocket motor cases, including the boosters for the Air Force's Inertial Upper Stage.

Hughes Aircraft Company: A National Resource For Space Exploration



The Hughes-built synthetic aperture radar, the sole scientific instrument aboard Magellan, cuts through the sulfuric acid clouds shrouding Venus to relay images of its surface, which are used to create a detailed topographic map of Earth's sister planet.

When Hughes engineers were honored at the 1992 Goddard Dinner in Washington this April for their role in unlocking the mysteries of Earth's sister planet Venus, it was yet another acknowledgment of the tremendous capabilities this long-time NASA contractor has provided our nation's search for knowledge and understanding of the solar system.

Hughes designed and built the synthetic aperture radar that is the heart of the Magellan project. This remarkable instrument has peered through the sulfuric acid clouds that mask the planet to create a detailed topographic map of its surface. Today, according to Tony Spear, Jet Propulsion Laboratory's Magellan project manager, a more complete topographic map of Venus is available than exists of planet Earth.

For Hughes engineers, the Magellan project provided a chance to visit an old friend. The company designed and built the Pioneer Venus Orbiter and Venus Multiprobe spacecraft that was launched in 1978 on an eight-month mission similar to Magellan's. Today, 12 years later, the spacecraft continues to return radar images of the planet.

The company's role in the U.S. space program continues as the Hughes-built probe aboard the Galileo spacecraft, currently en route to Jupiter, prepares for its incendiary entry into that planet's atmosphere in 1995.

The U.S. space program is one of this nation's great accomplishments. From the Hughes-built Surveyor that demonstrated the feasibility of a soft lunar landing, to the spectacular images of Venus relayed by the Magellan radar, Hughes has been there. As the nation prepares for further explorations to the moon and Mars, one cannot help but look back and wonder where the program would be without a company like Hughes. Looking ahead one can only conclude this national resource will again be needed in the future.

Garrett Produces Fluid Control And Management Systems For Space Vehicles And Platforms

Hot gas (3700°F+) divert/attitude control thruster valve assemblies for the Lightweight Exo-Atmospheric Projectile (LEAP) program, developed by Garrett under contract to the Thiokol Corporation

Garrett Fluid Systems Division's experience in the fluid control and management area of space applications ranges from cryogenic and other types of fluids to gaseous materials and propellant gases.

Cryogenic Fluids
Garrett's work with cryogenic fluids such as liquid hydrogen and liquid oxygen includes involvement with the National AeroSpace Plane (NASP), Atlas launch vehicles, and Space Nuclear Thermal Propulsion.

Other Liquids
Nitrogen tetroxide, hydrazine, and water have been utilized or are being planned for use in the Titan, Brilliant Pebbles, and space station Freedom programs.

Gaseous Materials
Applications have been developed for the Atlas program and space station Freedom using helium, carbon dioxide, oxygen, and nitrogen.

Propellant Gases
High-temperature gases are proposed for systems on NASP, the Lightweight Exo-Atmospheric Projectile (LEAP), and Space Nuclear Thermal Propulsion.

Based in Tempe, Arizona, Garrett Fluid Systems Division works with fluid temperatures ranging from -452° to +4500°F and fluid pressures from 0 to 12,000 lbs/square inch. The product line includes:

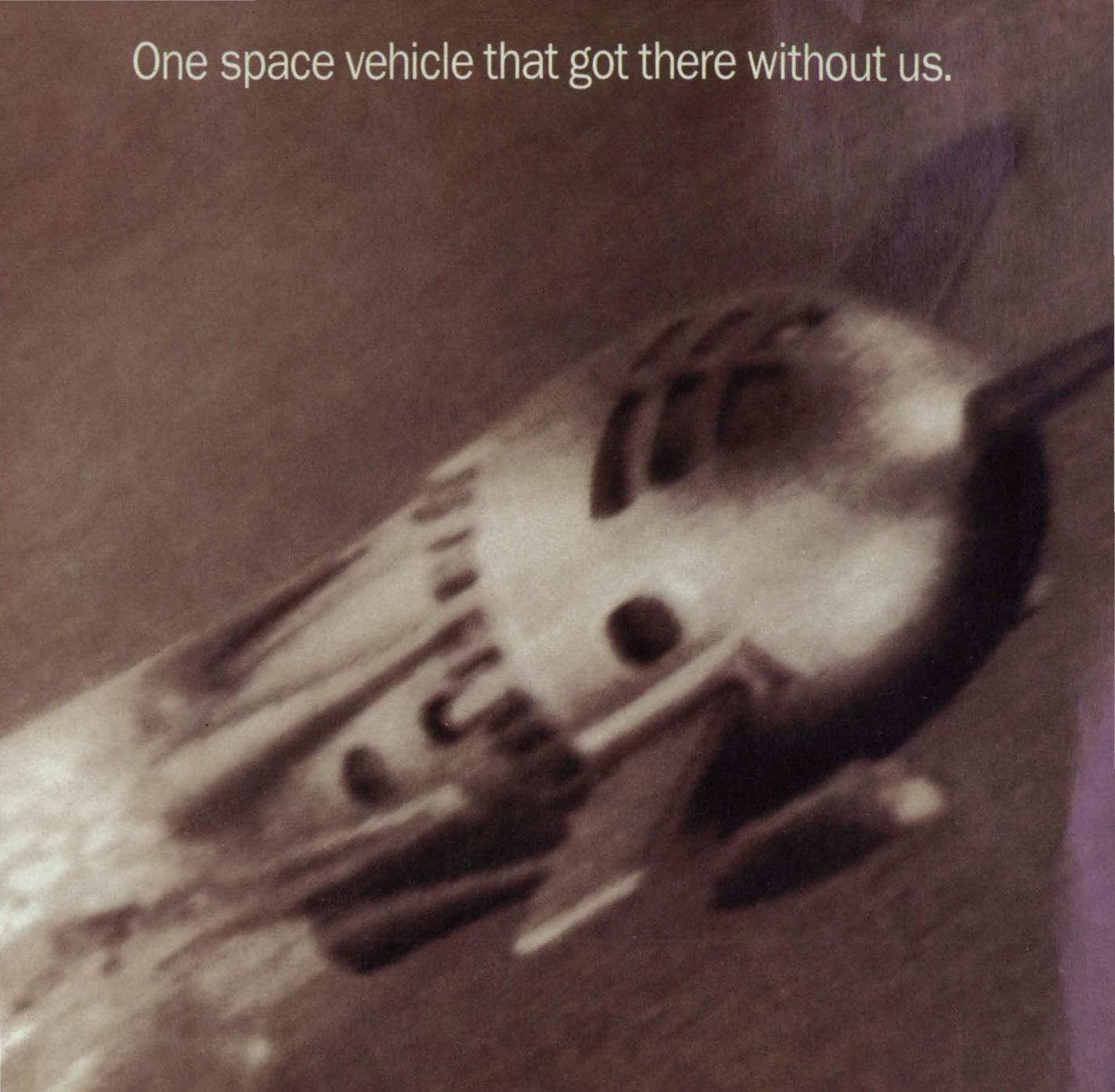
- pressure regulators
- pressure relief and vent valves
- tank prevalves
- emergency drain valves
- divert/attitude control thruster valves
- mono propellant tank pressurization systems
- fluid pumping systems

In addition to manufacturing products, Garrett has extensive analysis and modeling capabilities to assist customers in the design of components and systems. This capability extends into the test area, where facilities exist to test hardware, including cryogenic products. Garrett has a remote test site capable of handling materials such as hydrogen, oxygen, solid propellant gas generator, hydrazine, and nitrogen tetroxide.

No matter what fluid (cryogenic, gaseous, or liquid) the application must manage or control, Garrett Fluid Systems can do the job. For more information call (602) 893-4421.

Cryogenic (liquid oxygen) boil-off valve for the Atlas launch vehicle program, developed under contract to General Dynamics Space Systems Division

One space vehicle that got there without us.



It wasn't that long ago when the only space vehicles around were ones that landed on planets with names like Mongo. Then along came Garrett Fluid Systems Division.

Our involvement in fluid control systems, space valves, dynamic space power and specialized actuators spans the history of the space program itself. From Atlas, Titan, Saturn and Mercury to Space Station Freedom.

As the world leader in fluid systems technology, we're generating the solutions to the challenges of new generations of launch vehicles, space platforms and NASP-type applications. Our expertise includes a wide variety of systems. Thrust vector control, exhaust nozzle extension control, stability augmentation, fluid control, space power, propulsion management, separation and recovery. Plus complete facilities for testing and analysis.

As long as there are systems to be controlled, nozzles to be directed, rockets to be stabilized and power to be generated, contact us at **Garrett** Fluid Systems Division, 1300 West Warner Road, Tempe, AZ 85284. (602) 893-4420.

For More Information Circle No. 511

Allied Signal *Aerospace*

Semiconductor Laser manufacturing. Worldwide. World-class.

With our new state-of-the-art manufacturing facility in Simsbury, Connecticut, Ensign Bickford Aerospace answers the urgent need for military standard 800nm high power semiconductor lasers in production quantities and at reasonable cost.

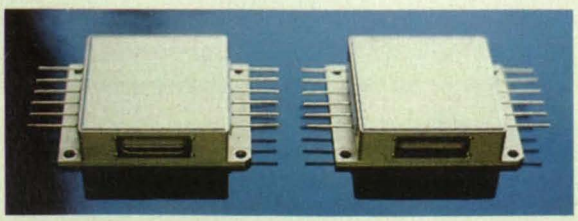
Our high power diodes and arrays come in various packaging configurations tailored to meet your needs. Whether you require fiber coupled, window configuration, or open heat sink, we manufacture devices in volume to make your program an economic reality.

We now support customers in areas ranging from optical pumping of solid state materials, and proximity and ranging for the military, to therapeutic and diagnostic medical applications.

High power semiconductor laser diodes in production quantities.

The new Simsbury facility, dedicated solely to the production of high power laser diodes, represents significant opportunities for designers in a wide variety of fields.

For more information call the Ensign Bickford Aerospace Marketing Department today.



Various packaging configurations to meet your specific needs.

See us at Booth #3770

ENSIGN BICKFORD AEROSPACE

ENSIGN BICKFORD AEROSPACE COMPANY
640 Hopmeadow Street, P.O. Box 427,
Simsbury, CT 06070, (203) 843-2630

For More Information Circle No. 514

Ensign Bickford Aerospace

The Leader In Ordnance Initiation Systems

After 40 years of experience in manufacturing ordnance initiation systems, the Ensign Bickford Aerospace Company, Simsbury, Connecticut, has developed the most advanced ordnance initiation system to date: the laser ordnance initiation system.

The laser ordnance initiation system is comprised of four major components: the laser firing unit, which generates the laser energy; the input\output interface, which controls all ARM, FIRE, DISARM, SAFE, and TEST conditions; the energy transfer system, which consists of a fiber optic harness to transfer laser energy from the laser firing unit to the initiators; and the pyrotechnic or explosive initiators themselves, which do the actual work such as motor ignition, battery initiation, stage separation, and payload dispersement.

The laser initiation system eliminates the design and manufacturing constraints associated with current ordnance initiation systems. Standard non-laser systems use sensitive explosive materials and electrical signals that require extensive safety and handling procedures. These systems are susceptible to electromagnetic interference (EMI), radio frequency interference (RFI), and static discharge. The laser ordnance initiation system eliminates all of these concerns.

Ensign Bickford Aerospace Company intends to continue its leadership role in the manufacture of advanced ordnance initiation systems into the next century. One of the many ways it is doing this is through continued investment in new technology, such as the construction of the new high-power semiconductor laser diode facility pictured on the preceding page.

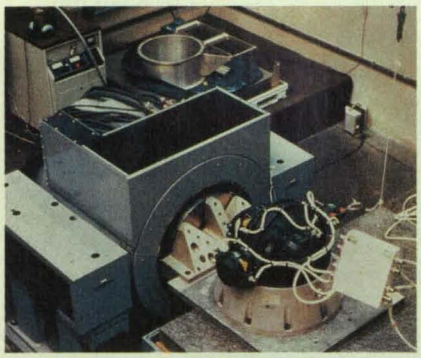
Ensign Bickford Aerospace Company is harnessing laser energy and putting it to use for your specific applications.

Ensign Bickford Aerospace Company is committed to the manufacture of advanced laser systems for ordnance initiation, and expects these systems eventually to become commonplace on launch vehicles such as the Titan IV booster shown above.

NTS Offers Unique Testing Capabilities

The Largest G-Force System in the World

National Technical Systems' Unholtz-Dickie T1000 and T4500 shaker systems have achieved vibration testing levels never before approached. Custom-made for NTS, the two shakers are driven by totally separate 120 and 180 kVA amplifiers. When interconnected into a single 300 kVA system, the T1000 generates in excess of 24,000 force-lbs., while the T4500 generates more than 45,000 force-lbs. Displacements up to 1 3/4" can be achieved. Use of the giant shaker systems virtually eliminates the need for band splitting on high-level random vibration tests.



Acoustic Levels Above 170 dB

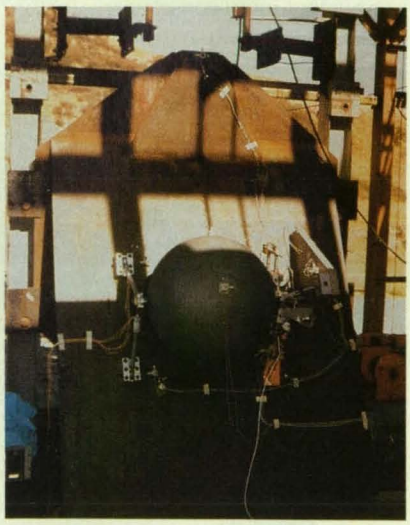
A progressive wave tube capable of producing sound levels above 170 dB was developed to test the flaps for a new high-performance military aircraft. Capable of testing items 6 ft. x 4 ft., it complements NTS' 5000 cu. ft. and 80 cu. ft. reverberant acoustic chambers.

In the photo below, a skin section of the National AeroSpace Plane (NASP) is being tested simultaneously at a temperature of 3000° F and a noise level of 165 dB.

Pyroshock Testing—Setting the Standards

NTS is at the forefront in establishing standards for pyrotechnic shock testing, such as ordnance-included, shaker-simulated, metal-to-metal impact, and laser doppler displacement. The metal-to-metal impact facility shown in the photo below simulates high-G pyrotechnic shock and is able to induce 3 axes simultaneously. Multi-channel, wide-band recording systems are used for accurate data acquisition.

Electrodynamic exciters used for pyrotechnic shock simulation can accept loads up to 1000 pounds and produce peak shock spectrums up to 4000 Gs. Shock spectra can be controlled with 1/12 octave equalization.



Emissions Testing From 20 Hz to 40 GHz

NTS' EMC/EMP capabilities include emissions testing from 20 Hz to 40 GHz, utilizing the Hewlett-Packard μP-based spectrum analyzer system; EMP test and signal analysis; radiated susceptibility and electrostatic discharge testing.

In-house automatic equipment can rapidly produce an X-Y recording of conducted or radiated emissions to demonstrate compliance with MIL-STD-461A/B, FCC Class A or B, VDE regulations, and other military/customer specs.

Shielded rooms and an open-field test site are also available.

High-Gs Centrifuge Testing

NTS' acceleration testing facilities include centrifuge diameters from 1 ft. to 102 ft. for payloads weighing up to 20,000 lbs. and sizes exceeding 15 ft. square. Tactical rocket motors can be fired under acceleration test conditions, or time versus G profiles can be generated to duplicate fighter plane maneuvers or space vehicle launch and reentry. The company's special 1000-G centrifuge can handle test items weighing up to 250 lbs., making it the highest-capacity machine of its kind in the country.

NTS®

1536 E. Valencia Drive
Fullerton, CA 92631

Ten laboratories nationwide:
West: (714) 879-6110
East: (508) 263-2933

Scramble It!

It's a work of art!
Your latest design — the prototype for a
ajor production order.
But now you've got to make sure it survives
e vibration, shock, acceleration and acoustic
vels your application requires.
That's where NTS can help.
We'll scramble it.
We've spent 27 years testing satellites, HUDs,
tos and trucks, electronic equipment, steam
nerators, computers, aircraft and missiles.
r industry, NASA, DOD, and hundreds of
mpanies including every major defense
ntractor in the United States.
We provide some of the world's most sophis-
ated engineering and test capabilities: shakers
t generate more than 45,000 force-lbs . . .
25,000 g's pyroshock . . . 800 g's acceleration
acoustic levels to 179 dB. And chambers for
nearly every environment conceivable.

We test hazardous products, high temp-
erature/high pressure gases and liquids,
EMI/EMC, PCB/PWBs. And we perform
FMEA, finite-element and fault-tree analyse

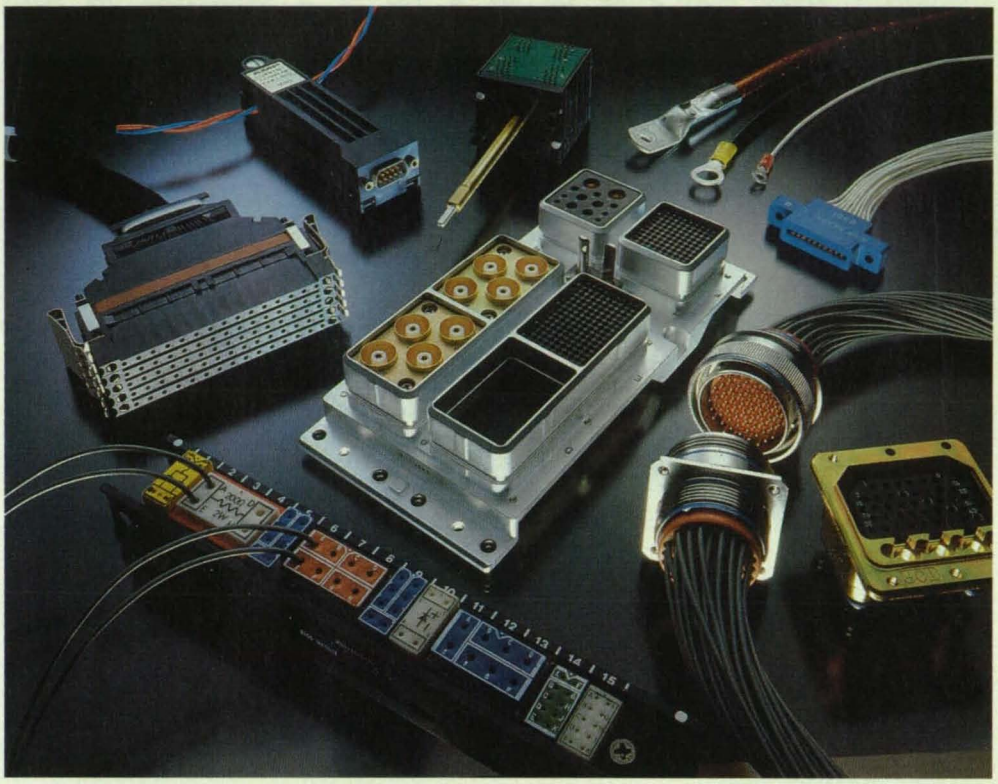
So make sure your creation won't scrambl
when the going gets tough .

Call NTS at (714) 879-6110 or in the East
(508) 263-2933. Or write NTS,
1536 E. Valencia Drive,
Fullerton, CA 92631

NTS

National
Technical
Systems

AMP: Fifty Years of Innovation



AMP is a leading supplier of connectors and associated technologies to the aerospace industry.

Fifty years ago, AMP began its journey with a few dozen people in several rooms producing simple uninsulated terminals and notched pliers. Within a few years, the company had become a leading supplier of connectors and matched tooling to the aerospace industry. Today, it is more than 25,000 people in 165 facilities in 31 countries, offering engineering analysis; design and development; manufacture of connectors, cables, and circuit boards; subsystem assembly; application tooling; and design, product, and system validation.

Expanding Capabilities

Interconnections have undergone a metamorphosis. Once considered incidental, they are now recognized as integral to the performance of critical systems from aircraft inertial guidance equipment to complex electronics in control communications. No longer simply a means of mechanical attachment, they often incorporate advanced electrical characteristics, miniaturization, and the sophistication necessary to handle various environmental rigors.

As interconnection technology experiences this dynamic evolution, AMP is leading the way with research and development in the areas of superconductivity, holography, cold-emission contacts, and others that will shape interconnections in the 21st century.

Customer Focus

AMP is dedicated to improving customer service. The goal of total customer satisfaction drives such efforts as increased use of cross-functional employee teams and simultaneous engineering to integrate manufacturing, development, logistics, and marketing functions.

Broadening service capabilities include a 24-hour facsimile service that automatically responds to dial-in requests for product literature and drawings, electronic application design system disks that enable customer CAD systems to rapidly specify interconnection requirements, and a new approach to packaging based on market needs and customer and distributor requirements.

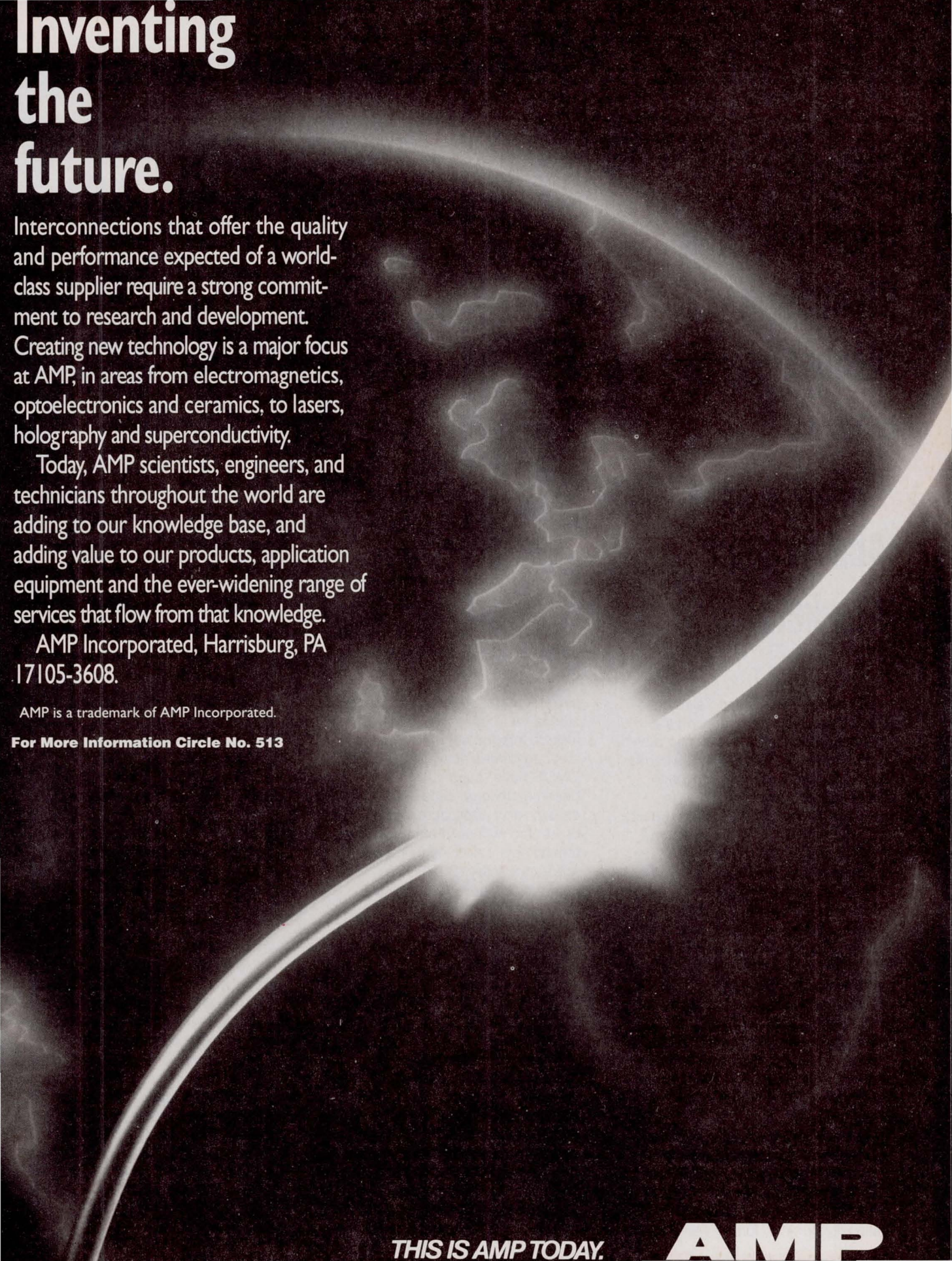
Teaming for Improved Responsiveness

Behind all efforts to improve responsiveness is the "teaming" approach to supplier/customer relationships, a specific and formal program for customer-driven product development. Teaming coordinates engineering personnel for joint design reviews and other activities, directs resources to solve program problems, and focuses on quick responsiveness to design and tool products that suit requirements, independent of industry trends.

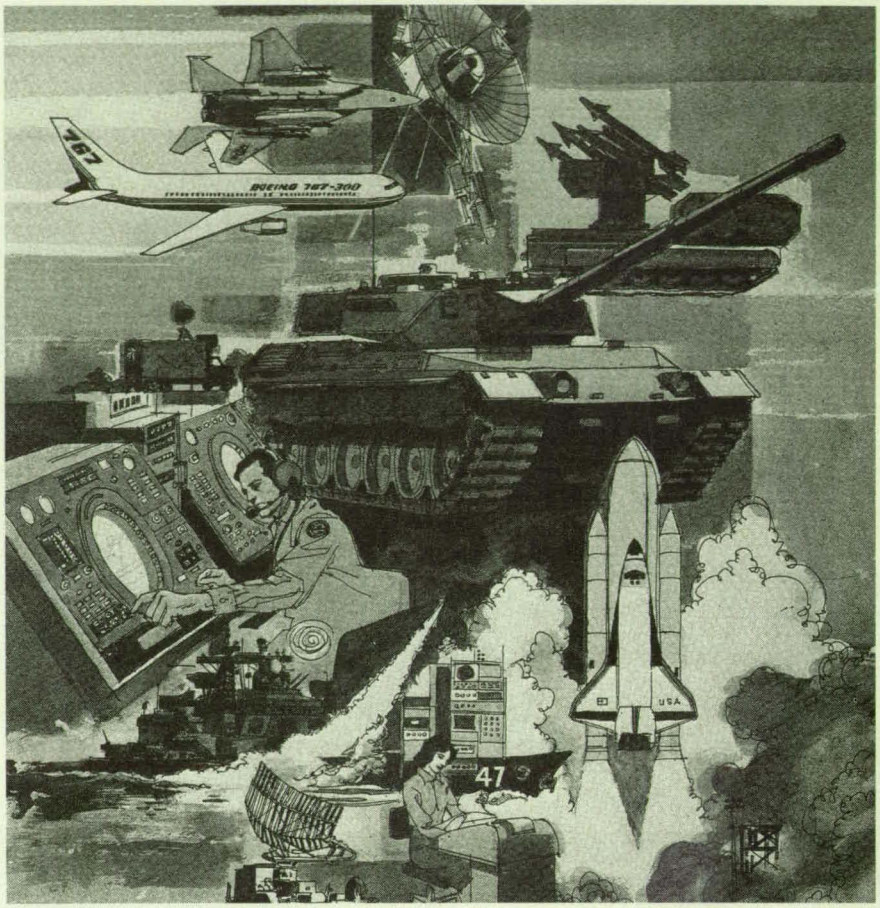
This is AMP Today

AMP has the resources needed to make the journey from concept to market—with capabilities far beyond supply of connectors to circuit design, analysis, simulation, and validation; systems development; and packaging design. All efforts are backed by an unequalled experience with everything from metal and plastic to heavy machinery and precision optics.

To learn more about AMP, call the Product Information Center at 1-(800)-522-6752.


Inventing
the
future.
Interconnections that offer the quality and performance expected of a world-class supplier require a strong commitment to research and development. Creating new technology is a major focus at AMP, in areas from electromagnetics, optoelectronics and ceramics, to lasers, holography and superconductivity.
Today, AMP scientists, engineers, and technicians throughout the world are adding to our knowledge base, and adding value to our products, application equipment and the ever-widening range of services that flow from that knowledge.
AMP Incorporated, Harrisburg, PA 17105-3608.
AMP is a trademark of AMP Incorporated.
For More Information Circle No. 513
THIS IS AMP TODAY.
AMP

Teledyne: Innovations In Switching Technology For Military/Aerospace And Defense Markets



Teledyne supplies a variety of solid-state relays to the aviation, aerospace, and defense communities.

Teledyne Relays and Teledyne Solid State have been serving the military/aerospace and defense markets for over 30 years. The California-based company has matured with these industry segments both in terms of new technologies and quality to meet their growing requirements.

The first product Teledyne developed was the TO-5 relay. This highly-innovative design concept provided a 50% space and weight reduction compared to other available relays, together with a quantum increase in reliability and resistance to environmental stresses.

As the demands of aerospace and defense projects increased, the company's products were manufactured and accepted for use in these projects, contributing to the success of the missions to which they were assigned.

Teledyne developed automated mass-production techniques that provided a degree of reproducibility, combining the economics of scale with the ultimate in quality and reliability. In time, further demands for circuit integration resulted in expansion of the relay product lines to include integral suppression and steering diodes as well as TTL and CMOS buffer stages. When it became obvious (circa 1969) that certain relay applications could best be served with solid-state switching technology, Teledyne pioneered the solid-state relay (SSR). The company's innovations include:

- the first solid-state relay
- the first DIP SSR for PC board applications
- the first military SSR
- the first hermetically-sealed SSR
- the first power MOSFET SSR

Teledyne's latest solid-state products provide a variety of "smart" options to the basic relay functions such as status (switch, flow, or trip status or a combination of these) to provide a built-in test function and overload protection (for example, short circuit or thermal overload). Thus, a single component can function as a relay and a remotely-resettable solid-state circuit breaker. All of these relays are designed and tested to MIL-R-28750 and applicable portions of MIL-STD-883.

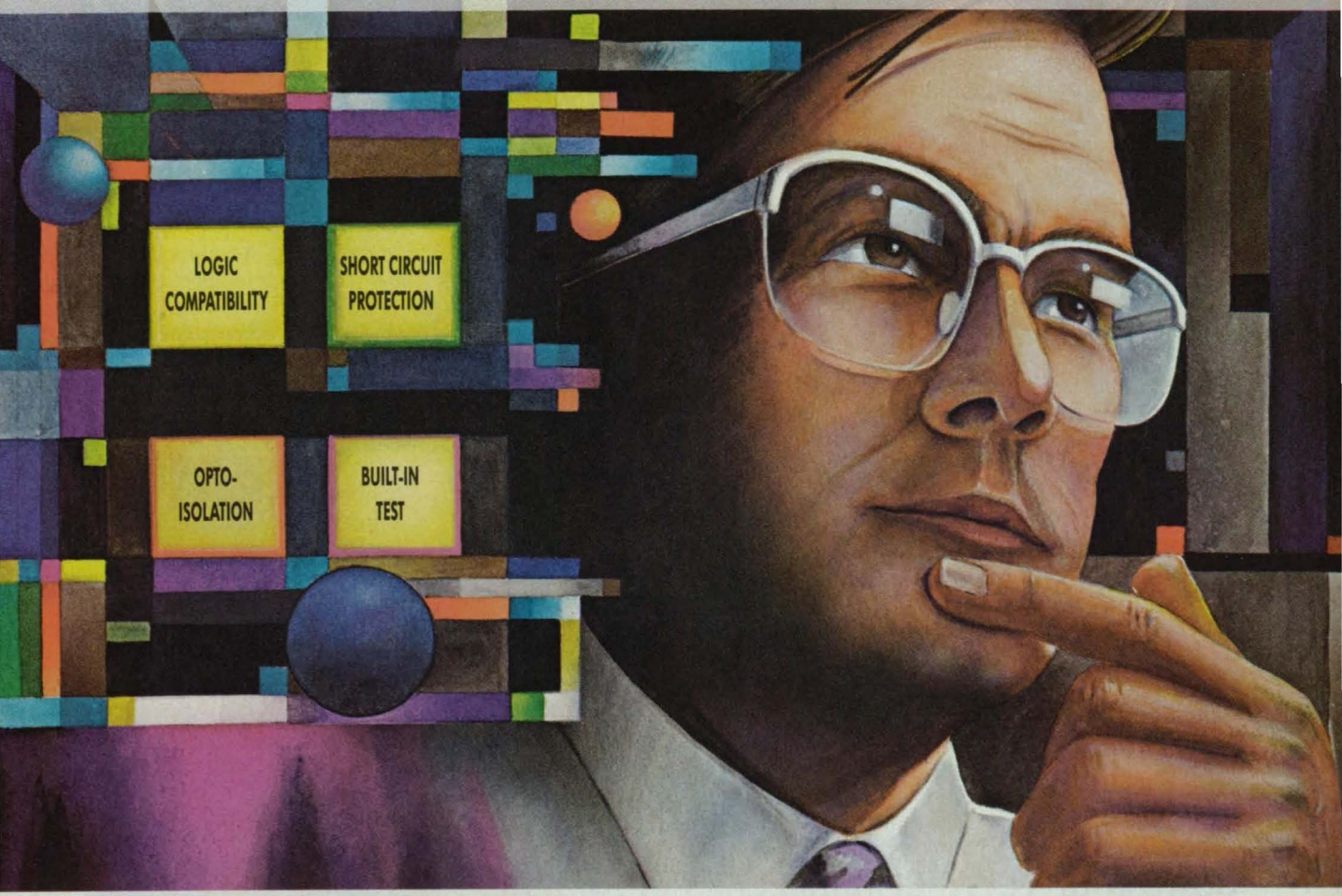
The company's commitment to excellence has been accepted in numerous aerospace/military programs. Teledyne products have been and are being used on the space shuttle, Voyager, AWACS, F16 and F18, Airbus A340, Boeing 700 Series aircraft (including the 737, 747, 757, 767, and 777), and most major military programs.

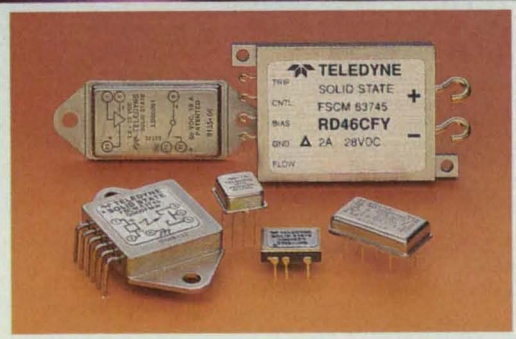
Still the technology leader, Teledyne Solid State and Teledyne Relays have proven to be an innovative, high-tech company that services the aerospace/military community. These same skills and experiences related to relays and switching circuits are available for commercial and industrial applications and customers. For further information contact:

Teledyne Relays/Teledyne Solid State
12525 Daphne Avenue
Hawthorne, CA 90250
213-777-0077
800-284-7007

DESIGNING YOUR OWN SWITCHING CIRCUITS?

WHY RE-INVENT THE WHEEL?





TELEDYNE SOLID STATE HAS IT!

If your system requires I/O or power switching and you're considering a discrete or hybrid circuit approach we should talk! And here's why—

• We now offer an extensive "menu" of military/aerospace solid state relays for DC, bi-directional, and AC loads from low level to 25 Amps.

• Our latest designs feature "smart" options such as: output status for built-in test, short circuit protection and CMOS logic compatibility.

• All of our relays are designed and tested to MIL-R-28750 and applicable portions of MIL-STD-883, and most are qualified to existing MIL slash sheets or DESC drawings.

• We've already selected, derated, sourced, and qualified the required chip components, i.e., opto-couplers, drivers, FETs, SCRs, etc.

And if what you need is not in our catalog, call 1-800-284-7007, or FAX 1-213-779-9161. Chances are we're already working on it.

For More Information Circle No. 517

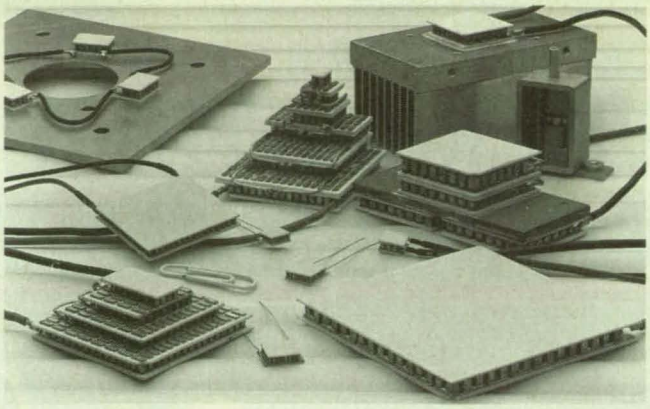
TELEDYNE SOLID STATE
A Division of Teledyne Relays

Home Office, 12525 Daphne Avenue, Hawthorne, CA 90250 • Telephone: 213-777-0077 • FAX: 213-779-9161

U.S. REGIONAL SALES OFFICES: EASTERN: (908) 272-0020, **SOUTHEAST:** (407) 682-9044, **NORTH CENTRAL:** (708) 529-1060, **CENTRAL:** (214) 348-0898, **WESTERN:** (408) 978-8899.
OVERSEAS: GERMANY, 0611-7636-0, **ENGLAND:** (081) 571-9596, **FRANCE:** 47-61-08-08, **BELGIUM:** (02) 673-99-88, **JAPAN:** (3) 3797-6956.

(Advertising Supplement)

Melcor's Products Ideal For Space Applications



Melcor's FRIGICHIP thermoelectric heat pump is lightweight, compact, and highly reliable, and can be stacked to achieve maximum temperature differentials.

Founded in 1959, Melcor, Trenton, NJ, is the world's leading producer of thermoelectric cooling devices. The company has applied its unique technical prowess to a variety of proprietary applications in the U.S. space effort.

Melcor's FRIGICHIP® thermoelectric heat pumps have proven ideal for the rigorous demands of the space program. Many of the primary characteristics of Melcor's products combine to make them particularly suitable for space use. These include their solid-state construction with no moving parts, assuring very high reliability; their compact design, which meets a critical criterion for space applications; and their exceptionally light weight, which remains a primary design consideration for space projects.

Overcoming Cooling Problems in Outer Space

Localized cooling of specific equipment and systems is an ongoing need in the space program. Vapor compression systems require substantial space and weight and depend on moving parts which can adversely affect reliability. Fans and heat sinks provide only limited cooling capacity and cannot provide precise temperature control. By contrast, thermoelectric cooling has none of these disadvantages.

As noted in the accompanying ad, single FRIGICHIP modules from Melcor can achieve maximum temperature differentials of approximately 65°C and pump tens of watts of heat. Even greater differentials can be achieved by stacking one module atop another, a process known as staging or cascading. A two-module cascade can achieve a temperature differential of 83°C or more; three- and four-stage devices can attain 105°C and 125°C, respectively. Single-stage modules range in cooling capacity from .22 watts to 125 watts and in size from 2 mm x 3 mm to 62 mm x 62 mm.

With an appropriate bi-polar controller, Melcor FRIGICHIPS—single or multi-stage—can provide cooling and/or heating for precise temperature control under fluctuating ambient temperature conditions.

Melcor is proud to be in its fourth decade of providing highly-reliable thermal management solutions to the space industry.

Photo-Sonics/IMC Helps NASA Document Shuttle Launches

A space shuttle launch is arguably the most documented event in the world. As the vehicle lifts from the ground, from 100 to 160 16 mm, 35 mm, and 70 mm film cameras, with focal lengths from 10 mm to 600 inches, are running at speeds up to 400 frames per second. Simultaneously, a hundred video cameras are running at 30 frames per second and dozens of 35 mm still cameras are recording minutiae by the millisecond.

All of this photo action takes place in the most abusive environment imaginable: flames and explosions everywhere; acceleration forces of 25 G in all three axes simultaneously; acoustic pressures to 160 dBm. And it gets hot enough to melt quartz. Steel decks flap like ocean waves, the heads of 3/8 inch bolts snap off, and hot debris flies in every direction, burning and pitting whatever it hits.

The footage these cameras capture provides critically important information to hundreds of engineers nationwide, from the Kennedy Space Center (KSC) to California. It provides post-launch status and diagnostic clues to what happened, so NASA officials can determine when, where, and under what circumstances the shuttle and its crew can be brought safely back to Earth. Each individual frame of film is examined by engine experts, structures experts, and vehicle experts.

They look to the film for answers: Which if any tiles were damaged? Were any control surfaces hit with debris? Did the tail service masts, umbilicals, and hydrogen vent arms all separate properly? Did the explosive bolts holding the vehicle shear off correctly? Did the roman candle igniters that start the main engines work properly? What's the color of the main engine exhaust?

Of the more than 100 16mm film cameras in use, about half are mounted "up close and personal"—only 20 to 70 feet from their objectives, which might be the exhaust blast from the awesome solid rocket boosters. These cameras need enough spatial resolution to identify and track debris as small as a paper clip so engineers can document their source, trajectory, and velocity, and accurately assess any impact damage.

Resolution of the old cameras (many with 20 years wear) had deteriorated, and their age made it costly to maintain and repair them. Even more important, though, was the pressing need to have cameras that could be reloaded in broad daylight quickly, easily, and reliably with film preloaded in magazines, not loose on reels; this lets you change film in less than a minute.

Four years ago, NASA decided it was time for an upgrade. The agency undertook a $23 million project to replace virtually all the cameras, control sequencers, lighting systems, and other elements of the photo observation system at KSC. For this replacement program, NASA has thus far selected Photo-Sonics Model 16-1PL and Model 35-4ML high-speed instrumentation cameras distributed by Instrumentation Marketing Corp. Inc. (IMC) of Burbank, California. These rugged high-speed film cameras are compact enough to fit inside NASA's existing protective enclosures. They feature the magazine loading vital for this application. And they are expected to provide another 20-year-plus lifecycle.

Magazine film loading is a critical issue at NASA. Not all cameras used to record a shuttle launch start at the same time. Those close up may be needed for only a few seconds, then the action is over; the explosive bolt has sheared or the umbilical has separated. Others at distant perimeter sites must record the entire scenario, from before ignition to after the vehicle is out of sight. When a countdown is suspended near time-zero, many of the cameras have already begun rolling, and their exposed film stock must be removed and replaced. Without magazine loading cameras, quick replacement of film in a hundred cameras is a major, time-consuming problem.

This article was written by Ken Poimboeuf of Kennedy Space Center and Bruce Totty of Photo-Sonics/IMC.

Miller Thermal: Masters In Aerospace Coating Technology

Aerospace design engineers have counted on the thermal-spray process to provide coatings for abradable seals, thermal barriers, and corrosion and erosion resistance to engine parts since the early 1950s. Coatings for critical engine parts are regulated by strict aircraft coating specifications that must be duplicated from part to part, and from one production run to another.

Plasma-sprayed coatings for critical applications require extremely accurate and repeatable control of the process parameters. Until now, these process variables have been dependent on the skill and technique of the operator using analog instrumentation. Repeatability errors of 100 percent were not uncommon, and the average range of error for plasma energy in the field is 35 percent.

Miller Thermal, Appleton, WI, recently introduced a plasma control system that improves control and repeatability of the plasma-spraying process. This system, a revolutionary new idea in plasma spraying, is especially helpful in reducing cost by computerizing adjustment and control of the thermal spray parameters.

The Model 4500 uses sophisticated data acquisition hardware and software to monitor, record, and control all plasma spray processing functions through preprogrammed spray parameter recipes. Parameters include Miller Thermal's proprietary closed-loop control of the net plasma energy—the actual energy output in the plasma arc. Incorporating the net plasma energy control into the automated process consistently provides peak performance and coating quality. Combining the closed-loop control of the net plasma energy with that of the powder, arc gas, and powder gas mass flows provides precise control of the complete plasma spray process. The system maintains repeatability of the process from one production run to the next despite normal part variations. Control of the net plasma energy results in a proprietary parameter that allows the system to monitor the real-time gun efficiency. The system then monitors the condition of the plasma gun and visually alerts the operator when components show signs of excessive wear.

Manufacturers are exploring many new and innovative uses for the plasma-spray process, including abradable seals, biomedical applications, corrosion protection, preparation of composite materials, spray-forming of parts, thermal barriers, and wear and erosion resistance.

The Model 4500 CPC system has the process control ability to do single, multi-layered, and graded (gradated) coatings in any combination based on the preprogrammed recipe. Integrated programs include complete system diagnostics, an extensive process data acquisition generator, and a comprehensive post-process data analyzer with trend evaluation capability.

The control module has a port for interfacing to various CNC controllers, or to interface with other robotic and manipulator systems. Additional ports and drivers provide remote computer access and auxiliary control. The module also has an eight-channel External Event Monitor interface for monitoring and interlocking various plasma-spray facility conditions preprogrammed into the recipes. This system may be equipped and specially designed to control six hopper/scale combinations, and to control three plasma guns from a centrally-located control module.

IF YOU CONSIDER YOUR 8MM TAPE DRIVE AS DATA INSURANCE,

EXATAPE™
8mm Data Cartridge
Shown Actual Size

THEN CONSIDER OUR 8MM EXATAPE™ AS THE PREMIUM.

Unlike standard, off-the-shelf 8mm video media, EXATAPE™ is designed for the 8mm data storage market. EXATAPE's rigid manufacturing specifications ensure maximum reliability and capacity to support the high recording density of your 8mm cartridge tape subsystem. In addition, an advanced media formulation results in extended archival/shelf life, increased reliability, greater durability and tape stability, and extended drive head life.

Whereas 8mm video media may be suitable for everyday video recording, irregularities and unpredictable quality can compromise data integrity *and* jeopardize drive performance.

So for superior performance in all of your 8mm data storage applications, choose EXATAPE from EXABYTE Corporation, the original manufacturer of all 8mm cartridge tape subsystems.

For more information call your 8mm tape drive supplier or EXABYTE today. And consider 8mm EXATAPE as your data insurance premium.

EXABYTE 8mm data cartridges, cleaning cartridges, and cartridge holders provide a total backup solution.

For More Information Circle No. 418

Headquarters 1-800-EXABYTE
Eastern U.S. (407) 352-5622, Ext. 82
Central U.S. and Canada (708) 953-8665
Western U.S. (408) 370-6107
Europe (Amsterdam) 31-3403-51347

EXABYTE Corporation 1685 38th Street Boulder, CO 80301

EXABYTE® THE CAPACITY TO SUCCEED


USA

NASA's shuttle shakes, rattles, and rolls with Spiralock.®

Self-locking fasteners.

During launch the main shuttle engines develop 400,000 lbs of thrust. And bone shaking vibration. NASA needed engine component fasteners capable of withstanding severe stress and vibration...but also capable of repeated re-use.

That narrowed it down to Spiralock. The unique female thread form that locks any standard male fastener firmly in place without resorting to split washers, deformed threads, nylon plugs, or chemical bonds.

NASA tests demonstrated that the fasteners in Spiralock threaded holes and nuts would not back off or loosen when subjected to 10 times shuttle specified vibrations. And, they stayed that way under that vibration loading for a period 10 times longer than called for.

NASA also wanted a 15-cycle reuse capability per fastener. Spiralock delivered 50, with no loss of clamping power.

How it works.

The female thread form in holes and nuts produced by Spiralock taps incorporates a unique 30° wedge ramp at its root. The ramp does not impede the free running of the fastener until clamp load is applied. Then, the crests of the male threads draw tightly against the wedge creating a continuous spiral contact along the entire length of the thread engagement, spreading the force evenly across all threads. Self locking, and stronger.

In standard 60° thread forms, most of the clamp force is concentrated on the first thread. And that translates to loosening. Or worse, fatigue failure.

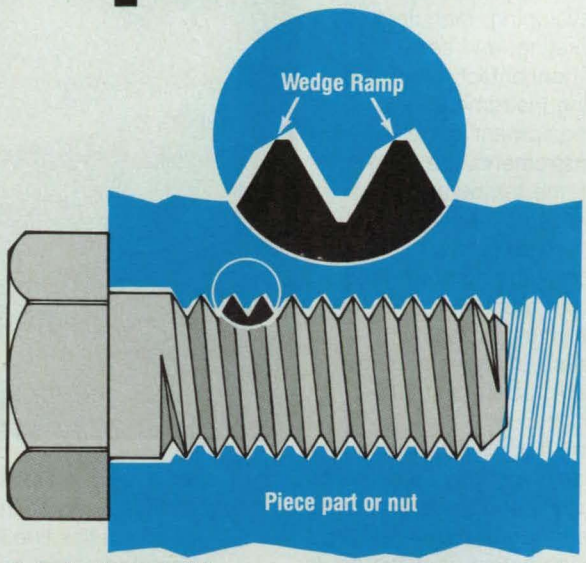
Additional benefits.

Since Spiralock threads have more clearance, they allow an exceptional free spinning assembly condition. That means lower costs and fewer fastener related rejects.

And, when it comes to aluminum or other soft materials, the ability of Spiralock to distribute the load evenly across all threads virtually eliminates stripping.

NASA found many more reasons to specify Spiralock. In fact, in each shuttle engine alone, they found 757 of them.

For more reasons to consider Spiralock for your shuttle, call or write for a free brochure. Or, send $25 for detailed test results.



Spiralock thread form.

Photoelastic study.

spiralock®

In North America Contact:
Detroit Tool Industries
Madison Tech Center
25219 Dequindre Rd.
P.O. Box 71629
Madison Heights, MI 48071-0629 U.S.A.
Phone: (313) 543-7800
FAX: (313) 543-1403
Toll Free Numbers
1-800-521-2688 U.S.
1-800-482-2679 Michigan

In Europe Contact:
EMUGE-WERK
Richard Glimpel/Postfach 25
Nurnberger Str. 96-100
8560 Lauf a.d. Pegnitz, West Germany
Telefon: 09123-1860 FAX: (09123) 14313

In Asia Contact:
OSG Manufacturing Company
Toyokawa-cho/Toyokawa-city
Aichi-pref./442 Japan
Phone: (05338) 4-7723 FAX: 5338-4-3197

For More Information Circle No. 606

Mikron: A Leader In Temperature Measurement

Mikron's M190 infrared thermometer is designed for research and critical process monitoring.

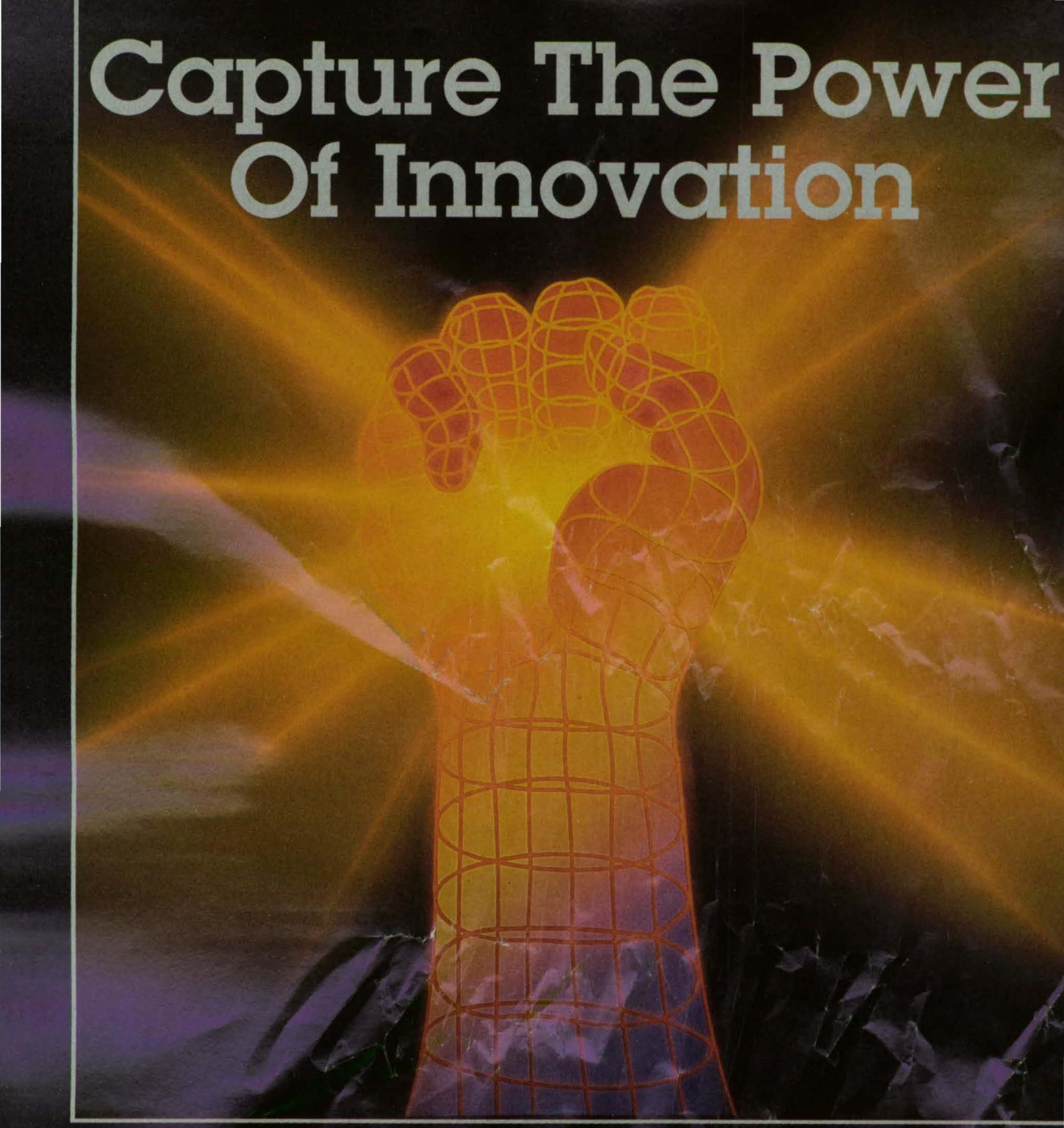
Mikron Instrument Company, Inc., Wyckoff, NJ, has been developing, manufacturing, marketing, and servicing infrared noncontact temperature measuring instruments and related equipment since 1969. These instruments are used to measure the temperature of moving objects, stationary objects, or surfaces where contact measurement would be difficult, hazardous, or impractical, and wherever rapid temperature changes must be accurately tracked instantaneously.

Mikron has also developed for research purposes a series of "blackbody" sources to accurately calibrate infrared thermometers, optical pyrometers, imaging equipment, and spectral radiometers, or to provide a radiation standard. Included in this line is a super-precision "metal freezing" blackbody source used as a primary radiation standard. This type of equipment has been supplied to NASA for vacuum and space research projects.

Other Mikron instruments used in space research include microprocessor-based fiber optic thermometers capable of accurately measuring temperatures from 100 to 3500°C. These instruments measure temperature in locations inaccessible to conventional infrared thermometers and isolate sensitive electronics from extreme heat.

Mikron's latest infrared thermometer, M190, was designed specifically for research and critical process monitoring. It incorporates leading-edge optical and thermometric technology and provides accuracies to 0.25% of reading. It is expected to find numerous applications in space research as well as in industry.

Capture The Power Of Innovation



This December, the nation's top technology managers will gather in Baltimore, MD to explore a gold mine of innovative ideas they can use to solve engineering problems, create new products, and help their businesses grow.

The event is Technology 2002, and you are invited.

Sponsored by NASA and *NASA Tech Briefs* magazine, Technology 2002 is more than a conference...more than a trade show...it is a vital resource that will put you in direct contact with the premier technology developers and tech transfer experts in federal laboratories and industry.

Technology 2002 will show you how to tap into the government's $70 billion technology storehouse and turn taxpayer-supported innovations into profitable products. And it will alert you to a wealth of patent licensing and cooperative R&D opportunities in areas defined by the White House as critical als and manufacturing techniques, artificial intelli gence, electro- and opto-electronics, compute software, and biotechnology.

You can attend dozens of meetings this year an spend countless hours searching for new ideas t improve your business...or you can invest thre days at Technology 2002 and discover -- in on place, at one time -- the best technology Americ has to offer.

For complete registration information, call (800 944-NASA or circle number 528 on the Reade Action Card (page 145).

TECHNOLOGY
2002
the third national technology transfer conference & exposition
December 1-3, 1992

NOVESPACE

THE BEST WAY TO GET READY FOR SPACE IS PARABOLIC FLIGHT

Opportunities

- Life science and training
- Fluid mechanics experiments
- Technological test

Your advantages

- Cost efficiency
- Short preparation time
- Your own experimenter

Our guaranties

- Versatile and tailored service
- Contractual basis
- Just one go-between

NOVESPACE

NOVESPACE
15, rue des Halles - 75001 PARIS France
Tél. : 33 (1) 42 33 41 41
Fax : 33 (1) 40 26 08 60

For More Information Circle No. 351

LOW COST MICROGRAVITY IS OUR BUSINESS

Image-Processing Software for a Hypercube Computer *(continued from page 96)*

CIPE attempts to maximize memory for data and minimize data I/O because of the data-intensive nature of image processing. Incremental loading of functions minimizes usage of memory for functions, thus maximizing the memory available for data. Data I/O is minimized by employing a policy of keeping data resident. This policy is particularly important because there is a serious data transfer "bottleneck" between the host and hypercube computers.

This work was done by Meemong Lee, Alan S. Mazer, Steven L. Groom, and Winifred I. Williams of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 98 on the TSP Request Card.*

NPO-18169

Program for Simulation of Trajectories and Events

Common features of various simulations are combined into one software package.

Lyndon B. Johnson Space Center, Houston, Texas

The Universal Simulation Executive (USE) computer program accelerates and eases the generation of application programs for the numerical simulation of continuous trajectories that are interrupted by or that contain discrete events. USE is written in the Ada programming language. It was developed to facilitate the simulation of multiple spacecraft trajectories with such discrete events as one spacecraft crossing the equator, two spacecraft meeting or parting, or firing a rocket engine. However, USE could also facilitate the simulation of such phenomena as the operation of a chemical batch processing factory.

USE applies to those trajectories or other continuously evolving or propagating phenomena that can be represented by the generic first-order differential equation $\dot{x} = f(x,t)$; where x denotes a scalar, vector, or matrix of the evolving quantity or quantities, t denotes time, and f denotes any appropriate function. All simulations of such phenomena have some structural, procedural, and software features in common. USE incorporates these generic features so that the user does not have to reconstruct them for each new simulation. In particular, it enables the programmer to build both trajectory-generating programs (principally, those that integrate $\dot{x} = f(x,t)$ and postprocessing programs (principally, those that interpolate between integration points) with a common set of software modules.

USE provides an executive logic structure that can be modified by simple scripts to simulate many different combinations of interacting phenomena and events. Both propagation and discrete events are represented in the USE executive routines in a general way. Consequently, it is relatively easy to set up a specific simulation because the programmer has only to instantiate the generic logic.

USE includes the following:

- **Integrator_generic**. This software incorporates a number of integration algorithms.
- **Interpolator_generic**. This is the interpolation analog of Integrator_generic. It enables postprocessing programs to look and work like the corresponding trajectory-generating programs and to be built from the same parts.
- **Event_package_generic**. This software controls the simulation of discrete events. An event is triggered when a time-to-go function reaches zero.
- **Regula_falsi**. An event could be triggered by the attainment of a specified state (e.g., location, temperature, velocity, or the oc-

currence of another event) instead of by waiting for a specified time. Regula_falsi computes a time-to-go function that reaches zero when the specified state is attained.

- **Input_generic**. As its name suggests, this is a generic input routine that simplifies the control of input data.
- **Use_exec**. This software defines the types of information needed to control application programs and to effect communication between parts of programs.
- **The Driver Routine**. In Ada, it is convenient to do all the instantiation in one routine called the "driver," which assembles the parts and provides overall program control.

With the help of USE, the programmer develops routines that control the simulated discrete events and time-to-go functions that "trigger" them. If integration is needed, the programmer also develops an equations-of-motion routine. The user must also develop routines that need input. Then the user constructs the driver routine, which instantiates the generic routines with those specific to the simulation, and which contains the control loop specific to the simulation. Thereafter, the USE logic takes charge of integration, advancing time, stopping at all discrete events, and controlling the sequence of events.

This work was done by Robert G. Gottlieb of McDonnell Douglas Corp. for **Johnson Space Center**. *For further information, Circle 112 on the TSP Request Card.*
MSC-21816

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Creative-Dynamics Approach to Neural Intelligence

Non-Lipschitzian dynamics can represent neural networks that behave somewhat creatively.

A paper discusses an approach to mathematical modeling of artificial neural networks that exhibit complicated behaviors reminiscent of the creativity and intelligence of biological neural networks. In this approach, a neural network is treated as a non-Lipschitzian dynamical system — a concept that was described in "Non-Lipschitzian Dynamics for Modeling Neural Networks" (NPO-17814), *NASA Tech Briefs* Vol. 14, No. 9 (September, 1990) page 97.

Dynamical systems of the general type are considered to have points of equilibrium. The subsequent behavior of a Lipschitzian system is determined for all time, once the initial dynamical parameters are specified. In that they behave rigidly by always responding in the same way to the same set of stimuli, older mathematically modeled neural networks can be likened to Lipschitzian systems.

A non-Lipschitzian system can behave unpredictably near its equilibrium points because the solutions to its dynamical equations at these points are nonunique. Near such a point, the system can produce a nondeterministic (e.g., multiple-choice) output in response to a deterministic (e.g., periodic) input. This unpredictability, possibly in combination with a functional or algorithm for evaluating the various unpredictable outputs, serves as a crude mathematical representation of creativity or spontaneity.

An unpredictable system of the non-Lipschitzian type can be represented by coupled dynamical equations of activation and learning. The ability of the system to be activated spontaneously is based upon two mathematically pathological characteristics: The first characteristic is that the Jacobian of the equations is zero, and, as a result, the system has an infinite number of equilibrium points that occupy curves, surfaces, or hypersurfaces. The second characteristic is that at all the equilibrium points, the Lipschitz condition fails, so that the equilibrium points become terminal attractors or repellers, depending on the sign of the periodic excitation. Both characteristics engender multiple-choice responses.

The paper shows that an unpredictable system can be controlled (that is, made at least partly predictable) by use of strings of signs (+, −), called "code strings," that uniquely define its behavior by specifying the directions of the motions at the critical points. By changing the combination of signs in the code string of a system, one can make it reproduce any prescribed behavior to within a prescribed accuracy. Thus, an otherwise unpredictable system is extremely flexible and highly adaptable to changes in the environment. Such a system can serve as a powerful tool for the mathematical modeling of temporal-pattern memories and of the recognition of complicated spatial patterns.

This work was done by Michail A. Zak of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Creative Dynamics Approach to Neural Intelligence," Circle 41 on the TSP Request Card.*
NPO-18154

Life Sciences

Hardware, Techniques,and Processes

Books and Reports

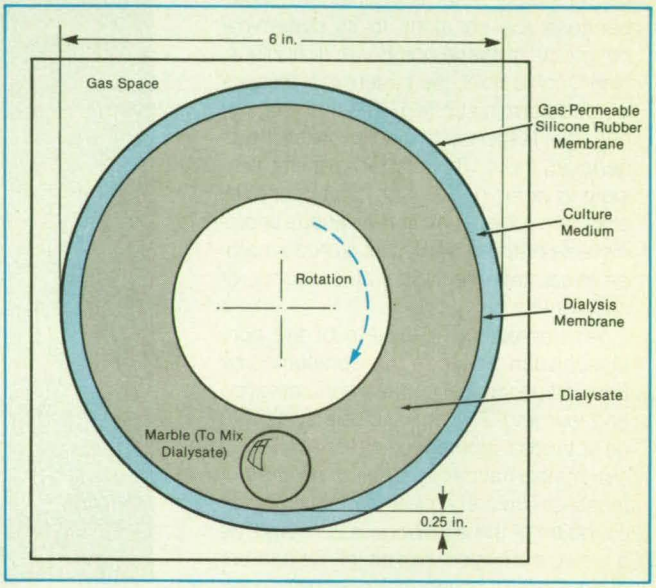
High-Aspect-Ratio Rotating Cell-Culture Vessel

Rotation of the vessel about a horizontal axis maintains the homogeneity of the culture medium.

Lyndon B. Johnson Space Center, Houston, Texas

A cylindrical rotating cell-culture vessel with a thin culture-medium layer of large surface area provides for the exchange of nutrients and products of metabolism with minimal agitation. The rotation of the vessel causes the averaging, to nearly zero, of the buoyant forces that would otherwise tend to separate those components of the culture that have different densities. The vessel enables the growth of cells in a homogeneous distribution with little agitation and, consequently, little of the shear stress that damages mammalian cells. Sustained intercellular spatial orientations, which may be important in some cultures, are not disrupted by fluid mechanical stresses.

The culture medium is contained in a space of 0.25 in. (6.4 mm) radial thickness



The **Rotation of the High-Aspect-Ratio Culture Vessel** about its horizontal axis prevents gravitationally induced stratification of the culture medium. The thin culture-medium layer is sandwiched between a gas-exchanging silicone-rubber membrane on the outside for gas exchange and a dialysis membrane on the inside for the exchange of nutrients and products of metabolism.

at a diameter of about 6 in. (15 cm) between two thin cylindrical membranes (see figure). The inner and outer membranes both rotate with the vessel at the same angular velocity, so that they carry the culture medium along at the same rotational rate, without causing shear in the culture medium (except briefly during startup).

The outer membrane is made of gas-permeable silicone rubber, which confines the culture but permits exchange of oxygen, carbon dioxide, and other gases with the laboratory gas-control system or with the atmosphere. The inner membrane is a dialysis membrane that also confines the culture but permits the exchange of nutrients and waste products between the culture and a dialysate space inside the cylinder. Because the culture-medium layer is relatively thin, the concentration gradients that drive the exchange of gases, nutrients, and waste products do not exist along distances great enough to cause concentrations to deviate significantly from the desired levels. The partial pressures of the gases in the surrounding gas space are controlled by free exchange with the gas-control system or atmosphere, as the case may be.

The liquid in the dialysate space should be mixed by some mechanism; a rolling marble has been used. Products of metabolism can be extracted from the dialysate and soluble materials introduced into it without disruption of the cell-culture space. The exchange of gases may also be performed on the dialysate to increase the overall gas-exchange capacity of the vessels. Where a culture can withstand some agitation, the capacity of the vessel can be increased by increasing the thickness of the culture layer and providing some agitation to help distribute dissolved substances.

This work was done by David A. Wolf and Clarence Sams of **Johnson Space Center** *and Ray P. Schwarz of Krug International. For further information, Circle 144 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 18]. Refer to MSC-21662.

Is your subscription about to expire?

Check the expire date. If it is less than 6 months now is the time to fill out a new qualification form before your subscription expires.

Thermophilic β-Glycosidase

This enzyme could play an important role in the recycling of biomass.

A report describes the identification of a thermophilic β-glycosidase enzyme from an isolate of *Sulfolobus solfataricus*, sulfur-metabolizing archaebacteria that grow aerobically and heterotrophically to relatively high cell yields. This enzyme could be useful in the enzymatic conversion of cellulose to D-glucose and hence could play an important role in the recycling of biomass. In addition, its resistance to temperatures up to 77 °C could enhance its role in the breakdown of cellulosic products because the breakdown process could take place at such relatively high temperature.

In experiments described in the report, it was found that crude extracts from one of the isolates, called "P2," of *S. solfataricus* contained relatively high activities of thermophilic enzyme that hydrolyzed various glycosidic compounds, especially β-D-galactosides and β-D-glucosides. The following results were interpreted as indicating that the activities with respect to galactosides and glucosides are due to a single enzyme, which had previously been identified in a closely related isolate only as a β-galactosidase:

- A variety of denaturing substances and physicochemical conditions destroyed both activities at the same rate;
- The ratio between the two activities remained constant during an 850-fold purification;
- The result of purification was an essentially homogeneous enzyme, the electrophoretic mobility of which corresponded to that of both enzymatic activities; and
- Substrates of the two activities competed for the same catalytic site.

The purified enzyme hydrolyzed a variety of low-molecular-weight β-linked glycosides and could be used to account for most of the corresponding activities found in crude extract. (A comparison of the substrates hydrolyzed by crude extract and by purified β-glycosidase led to the conclusion that *S. solfataricus* also contains at least one other thermophilic glycosidase that hydrolyzes α-glucosides.) Kinetic analyses indicate that β-glucosides are the preferred substrates.

The liberation of aglycone from aryl β-D-glucosides was stimulated by alcohols in a manner that suggested specific interaction between alcohol and enzyme. The effect was accompanied by a shift in stoichiometry of the hydrolysis products, consistent with the transfer of glucosyl to the alcohol.

The β-glycosidase is apparently not effective against most high-molecular-weight polysaccharides. This fact limits potential industrial uses. However, because it exhibits specificity for both glycone and aglycone moieties of low-molecular-weight glycosides, it could also be used in the dairy industry for the removal of lactose from milk products. Other applications might stem from the relative resistance of this enzyme to denaturation by ionic detergents, urea, and organic solvents at high temperature. Finally, as a readily purifiable, easily assayable, thermophilic enzyme, it offers considerable promise as a model substance for elucidation of basic principles of structural stabilization of proteins.

This work was done by Dennis W. Grogan of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Catalytic Activities of 'β-Galactosidase' from the Extremely Thermophilic Archaebacterium Sulfolobus Solfataricus," Circle 73 on the TSP Request Card.*
NPO-18373

New on the Market

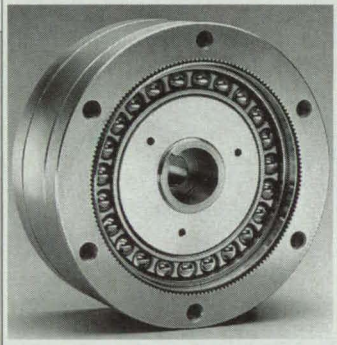
Jandel Scientific, San Rafael, CA, has released SigmaPlot 5.0, a 3D version of its **software for creating publication-quality technical charts and graphs**. The update incorporates one-step file merging, alignment and position tools, additional data import options, and expanded documentation. Graphs can be interactively rotated using a unique sparse matrix representation method. The software provides a full range of scientific features such as automatic error bars, huge dataset handling, nonlinear curve fitting, multiple axes, and regression lines.
For More Information Circle No. 786

The TMI-150 **ultrasonic scanning system** from Rohrback Cosasco Systems, Santa Fe Springs, CA, is designed for detection and documentation of internal corrosion, laminations, and inclusions in ferrous and nonferrous materials. The portable, real-time, cross-sectional imager tests composite materials within a standard thickness range of .20" to 6" and features on-screen alphanumeric annotation and a digital thickness gauge.
For More Information Circle No. 792

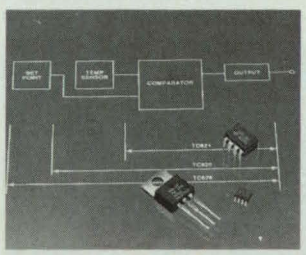
Western Graphtec Inc., Irvine, CA, has introduced 8-channel **array-corders** that combine the power and versatility of thermal array technology with the convenience of flatbed-style pen recorders. The WR5000 series recorders provide DC-10 kHz frequency response and allow signal expansion to 320 mm wide. Capabilities include one-touch trace expansion from 8 x 40 mm to 4 x 80 mm to 2 x 160 mm and 1 x 320 mm, separate or overlapping traces, list printing of all setup parameters, and 32 characters of interchannel test printing per channel.
For More Information Circle No. 778

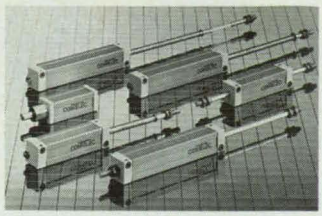
CIBA-GEIGY's Polymers Division, Anaheim, CA, has introduced a low-viscosity **epoxy system** suitable for filament winding in elevated-temperature applications. The high-performance resin system is based on Araldite®MY 721 tetrafunctional epoxy resin with HY 5200 non-MDA-based aromatic amine hardener. The resin/hardener combination produces a material that is easy to process, offers good fiber wet-out, and can withstand intermittent temperatures to 177° C.
For More Information Circle No. 780

RV series **reduction gears** from Harmonic Drive Technologies, Peabody, MA, offer high precision, low backlash, high torsional stiffness, and high shock loading capacity. With shock resistance five times its rated torque, the drive is suitable for applications requiring frequent stops, starts, and reversals. Models range in ratio from 30:1 to 185:1, with output torque ratings from 500 to 33,000 in.-lbs.
For More Information Circle No. 776



Teledyne Components, Mountain View, CA, has introduced the first **solid-state temperature sensors**. The new sensors directly convert temperature to a digital output, allowing the direct control of relays and switches, or an easy interface to any microcontroller. The model TC620 allows the user to program upper and lower temperature settings; the TC621 is designed to be used with an external thermistor for remote sensing applications; and the TC626 is pre-set at the factory in 5° C increments, for applications requiring a switch.
For More Information Circle No. 794

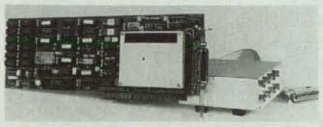




The KL series of short-stroke **position transducers** from Contelec, Marlborough, MA, features through or single shaft with 10, 25, or 50 mm stroke lengths and multi-turn potentiometers with 10, 25, or 50 turns. Standard resistances are 1 k or 5 k Ω; functional linearity is within 1.0%; case cross-section is 13 mm x 13 mm; and standard operating temperature range is -25° to 75° C. Linearity to within 0.25% is available, as well as spring return and flexible coupling to compensate for angular offset.
For More Information Circle No. 800

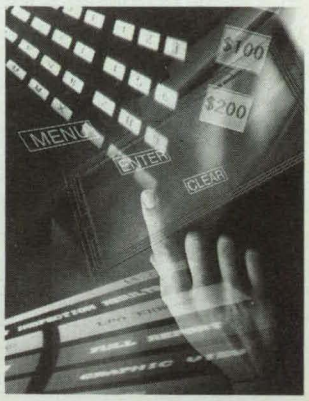
Coherent Inc., Palo Alto, CA, has introduced DIAMOND™, a cost-effective, modular, RF-excited, sealed **CO_2 laser**. Though only one tenth the size of equivalent lasers, DIAMOND processes materials 300% more effectively than ordinary CO_2 lasers at similar power levels, according to the manufacturer. Designed for OEM/industrial use, the new laser cuts, drills, and marks a wide variety of materials, from tissue paper to 0.15" thick ferrous material. Available in 75- and 150-watt power levels, it plugs in like a light bulb and requires no maintenance.
For More Information Circle No. 798

Rapid Systems Inc., Seattle, WA, has introduced a 12-bit, 2 MHz, PC-based **waveform acquisition system** that offers sample rates to 500 KHz with Windows 3.0-based software. Dual timebases allow users to simultaneously digitize fast and slow events. The system features four differential inputs; pattern, edge, and external triggers; and pretrigger, single shot, sequential, and post-trigger operating modes.
For More Information Circle No. 788



The industry's first Electronically-Erasable Programmable ROM **(EEPROM) 8051 microcontrollers** have been introduced by Siemens Corp., Santa Clara, CA. All four new macrochips, which are multi-chip modules that fit into the IC footprint, offer the enhanced on-board functionality of the EEPROM in a single package. EEPROM capability allows users to electrically erase and reprogram the microcontroller in seconds, facilitating the development of software and hardware.
For More Information Circle No. 796

Ultra-transparent **touch screens** manufactured by Transparent Devices Inc., Newbury Park, CA, are designed for placement directly in front of thin-film-transistor color LCDs. The screens' thin construction minimizes parallax while their index-matched, thin-film coatings greatly improve display contrast.
For More Information Circle No. 790



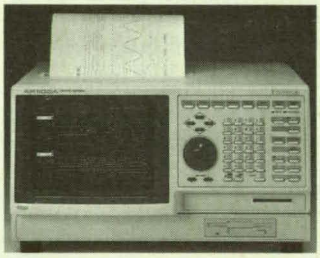
One-Wrap™ is an innovative single-part strap designed by Velcro USA Inc., Manchester, NH, for use as a **touch fastener**. Components can be mechanically bonded without adhesives, eliminating sticky edges and reducing costs. One-Wrap is available in widths to 12", and can be slit to narrow width or custom-produced to a wide range of cycle and strength characteristics.
For More Information Circle No. 774

ICS Electronics Corp., Milpitas, CA, has announced the model 4889L **bus extender** for IEEE 488/GPIB/HP-IB/CS-80 bus systems. Link distance is up to 25,000 meters using a single-mode fiber-optic cable, with no degradation of data transfer rate. The 4889L provides a data rate of 300 KB/sec, with a built-in protocol that guarantees error-free transmission.
For More Information Circle No. 784

A powerful new **uniprocessor system** called the STEP 486/50e Megacube has been released by Everex Systems Inc., Fremont, CA. Based on the Intel 486DX™ 50 MHz microprocessor, the system achieves 31 MIPS performance, the fastest available in a PC. It is designed for use in network file servers, multi-user or multitasking systems, high-end graphics workstations, and database programs.
For More Information Circle No. 782

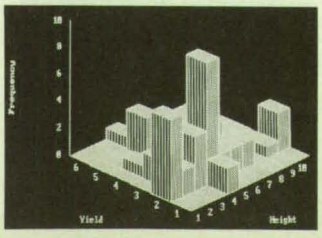
New on the Market

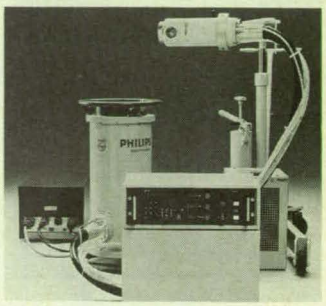
Yokogawa Corp. of America, Newnan, GA, has unveiled the AR Series of **waveform analyzing recorders**. These "all-in-one" digital analyzers integrate measurement, data processing, display, and recording functions into a compact, easy-to-use instrument. The model AR1100A features 4, 6, or 8 input channels with electrically isolated inputs, 100K samples/sec A-D converters, and simultaneous measurement on all channels. The AR1600 offers 12 to 16 channels, nonisolated, with 50K samples/sec sampling.
For More Information Circle No. 762



RTP Co., Winona, MN, has announced a series of **permanently anti-static ABS compounds**. Based on a noncarbon black system, the PermaStat 600 series products function without moisture dependence and cannot be removed from the surface of molded articles. They release no conductive contaminants, making them suitable for clean room manufacturing applications. They can be incorporated into calculators, chip carriers, conveyors, fan blades, film processing equipment, and printers.
For More Information Circle No. 772

CoHort Software, Berkeley, CA, is offering updates of its CoPlot, CoDraw, and CoStat **graphics and statistical software** for $159, or all three for $359. CoPlot 2.1 is a flexible graphics program that creates publication-quality scientific graphs, including 3D graphs that can be rotated and viewed from any angle. CoDraw 2.1 is WYSIWYG software that generates high-quality technical drawings, including apparatus and circuit diagrams. CoStat 4.1 is an interactive, menu-driven statistical program providing many sophisticated features associated with high-end micro and mainframe packages.
For More Information Circle No. 760





Philips Inspection Systems Group's MG 225 **x-ray inspection system** offers high accuracy and penetrating power, as well as compactness. The most powerful end-grounded x-ray system available, according to the Georgia-based manufacturer, the MG 225 uses a novel beryllium window dual-focus metal ceramic x-ray tube rated at 225 kv and 10 mA for maximum penetration.
For More Information Circle No. 764

Master Bond Inc., Hackensack, NJ, has formulated a cost-effective, one-component, highly-conductive **adhesive coating** for EMI/RFI shielding applications. Called AC84, it offers excellent shielding over a -62° to +14° C temperature range. It adheres well without pretreatment to most surfaces, including plastic, and is resistant to weathering, abrasion, humidity, and corrosion.
For More Information Circle No. 768

A low-cost, high-efficiency 1350 VA switch mode **AC power source** measuring less than 3-1/2" and weighing under 40 lbs. is available from Behlman, Lake Success, NY. It features a unique circuit that provides voltage foldback to maintain full-rated current into an overload without clipping AC output. The unit yields a continuously-adjustable voltage output of 0-135 VRMS and a frequency range of 45-500 Hz.
For More Information Circle No. 770

CubiCard, a **hardware controller for fuzzy logic engineering** applications, has been introduced by HyperLogic Corp., Escondido, CA, and Myriad Solutions Ltd., Cambridge, England. CubiCard combines an AT-bus-compatible circuit board with an enhanced version of HyperLogic's CubiCalc RTC product, which provides a platform for designing fuzzy logic systems.
For More Information Circle No. 766

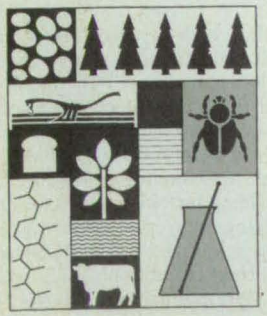
New Literature

Oriel Corp., Stratford, CT, has published a 238-page catalog of its **support hardware for electro-optical equipment**. New products include fully-programmable micro-positioning controllers for DC motor actuators, stand-alone or computer-driven stepping motor controllers, and visible diode lasers. Optical tables and benches, laser accessories, an extensive line of optical mounts, and manual and motorized micropositioners are also described.
For More Information Circle No. 704

The ninth annual edition of the Index and Directory of Industry Standards (IDIS) is available from Global Engineering Documents, Irvine, CA. The five-volume set comprises 113,000 standards, from 380 organizations, of which 12,000 are revised and 8000 new. IDIS provides a cross-referenced subject index and a directory of bodies responsible for developing standards.
For More Information Circle No. 706

The U.S. Department of Agriculture, Washington, DC, has published a catalog of **inventions available for license**. The inventions are arranged by field, including: farming equipment, herbicides, and plant growing; fatty acids and oils; food and protein; microorganisms, fungi, pharmaceuticals, and animal breeding; and textiles. The catalog includes federal licensing regulations and a license application form. It is available in print or through computer access to the TEKTRAN2 database.
For More Information Circle No. 712

Agricultural Inventions Catalog



Colwell-Kirtland International, Sunnyvale, CA, has released the second edition of its ***GPS Industry Analysis***. The study combines 600 pages of analysis and projections of the marine and aviation navigation, geodesy, military, and vehicle navigation and tracking markets. It features more than 60 color graphs and charts, profiles of over 60 GPS manufacturers, and specifications and pricing for current GPS receivers. Also available is an on-going subscription to GPS industry updates.
For More Information Circle No. 708

A short-form catalog from Truetime Inc., Santa Rosa, CA, introduces a line of affordable, precision **GPS timing products**. The new models include PC and VME plug-in synchronized timing generators, and portable as well as OEM board-level receivers.
For More Information Circle No. 714

A 28-page catalog from International Light Inc., Newburyport, MA, highlights **radiometers, photometers, spectroradiometers, and detectors** for applications ranging from UV curing to ozone depletion studies. Complete spectral and technical information for each combination of instruments, detectors, diffusers, filters, and input optics allows readers to specify over 1000 modular systems.
For More Information Circle No. 702

A full-color brochure from BP Chemicals' Advanced Materials Division in Santa Ana, CA, outlines its **advanced materials** capabilities. Its wide range of products includes ablatives and carbon, graphite, and silica textiles in such forms as unidirectional tapes up to 60" wide; straight and bias tapes; and structural broadgoods, and molding compounds. The company manufactures resins and prepregs under the tradename U.S. Polymeric. The 16-page publication covers technical innovations, program support, product development, and quality standards.
For More Information Circle No. 710

New Literature

Eastman Kodak's expanded desk reference offers information on more than 300 **imaging products**. Products are indexed according to image processing stage: capture, store, manage, or share. It features document scanners, microimagers, electronic and digital cameras, digital and optical disk storage systems, document and color image management systems and software, video inspection products, and copiers.
For More Information Circle No. 728

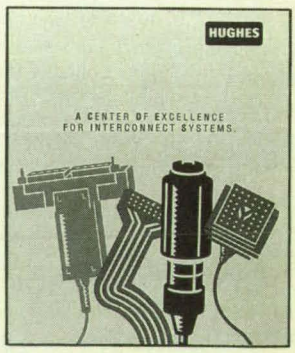
A book profiling successful industrial applications of **robotics and machine vision** has been published by the Robotic Industries Association, Ann Arbor, MI. Among the many applications examined are automotive assembly, bank note inspection, pill packaging, floor care, and laser cutting. Intended to help companies become more competitive, the book is available free to firms that send a written request specifying their application needs.
For More Information Circle No. 724

Solutions to heat transfer problems, custom-engineered by Lytron/Alpha United, Woburn, MA, are highlighted in a new catalog. Design and manufacturing capabilities are available for high-efficiency, compact fin and tube heat exchangers and thermal subsystems, including ultra-lightweight custom cold plates, card boxes, and plate fin heat exchangers.
For More Information Circle No. 722

An application note released by Neural Computer Sciences, Southampton, UK, examines how **neural networks** may be used to automatically predict time-related data. Neural networks, computer-based artificial intelligence that emulates human analytical processes, are relevant to activities such as forecasting movement of financial markets. The networks can be constructed to handle time-varying input data, incorporating cyclical movements as well as chaotic time series.
For More Information Circle No. 726

Electronic Space Products International, Agoura Hills, CA, has released a 438-page catalog detailing its **high-purity metals, alloys, chemicals, single crystals, rare earths, and exotic and precious metals**. The materials are designed for use in sputtering targets, vacuum deposition and evaporation, ceramics, fasteners, and other high technology and research applications.
For More Information Circle No. 718

A 16-page brochure from Rodenstock Precision Optics Inc., Rockford, IL, describes a wide range of precision **lenses, components, and sub-assemblies for visible and IR optical applications**. Lenses include enlarging, F-theta flat field, graphic arts, laser beam expanders, laser diode collimating and focusing, and medical x-ray. The component selection features beamsplitters, filters, mirrors, and prisms, while available sub-assemblies include test equipment, image intensifiers and processing recognition equipment, and laser material processing systems.
For More Information Circle No. 720



A four-color brochure showcases **interconnect products and technologies** available from Hughes Interconnect Systems Division, Irvine, CA. The 16-page publication describes high-density connectors, multi-chip module carriers, controlled impedance PCB interconnects, semiconductor test heads, circular and rectangular connectors, fiber optic termini, and testing services. It also outlines a new program providing customers access to engineering and manufacturing resources in other Hughes Aircraft and GM Hughes Electronics divisions.
For More Information Circle No. 716

Subject Index

(Continued on page 161)

(continued from page 12)

Heidi Jacobus, president of Cybernet Systems Corp., displays the PER-Force handcontroller, which offers force reflection for general-purpose applications.

as you get closer to it."

The controller works best, he said, when there is a one-to-one relationship between the movement of the stick and the range of motion at the other end. However, if an operator must work across very large areas, the control can be scaled so that slow motion of the control stick moves the slave robot greater distances that fast motion.

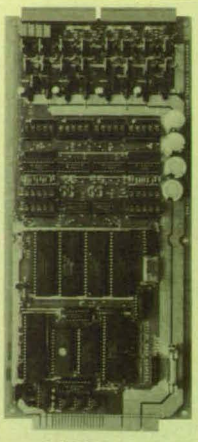
Cybernet researchers continue to investigate human factors related to the controller. "Some of our findings have been counter-intuitive, such as evidence that a little base-line friction is better than none," said Mr. Jacobus. "Apparently, it feels more natural to the operator."

The Jacobuses expect application of the handcontroller to broaden, particularly in the fields of industrial machine operation, interaction with graphical simulations, and maintenance and other operations in hazardous environments. Heidi Jacobus cites as especially promising its use in driving unmanned robotic vehicles. "A steering wheel could take the place of the handle," she said. "It's important in remote driving to have some feel of the operation, otherwise the vehicle could be rattled apart before you realized it."

The forces generated by the handcontroller are user-programmable, and can represent phenomena both real and virtual, in addition to actual robotic machine contact. The stick can help keep a pilot on a preferred flight path, with increasingly resistant force as the aircraft veers off course. Further, the forces can represent various sensor readings, as well as electromagnetic, thermal, and fluid force fields computed by CAD systems or dynamics modelers. In a system where surface texture is being analyzed optically, the controller could "transmit" a bumpy feel to correspond to surface defects even though no physical contact occurs.

One of the most innovative of the handcontroller's applications is in designing molecules. Programming the handcontroller to reflect various atomic forces within a molecular simulation allows chemists to move around within the model and "feel" where a molecule might be receptive to alteration. Here, as elsewhere, the controller allows researchers to get hands-on experience where no human hand could ever venture. ❑

***Editor's note**: Cybernet will demonstrate the PER-Force handcontroller this December at Technology 2002, the third national technology transfer conference and exposition, in Baltimore, MD. For more information about the Cybernet invention, contact: Heidi Jacobus, President, Cybernet Systems Corp., 1919 Green Road, Suite B-101, Ann Arbor, MI 48105.*



MCB-4

FEATURES:

- Up to 2 Amp per motor winding
- Simultaneous operation of all motors
- Optoisolated power section
- Limit and home inputs
- RS-232 and RS-485 communication port
- User friendly instruction set

MCB-4 COMPLETE 4 STEPPING MOTOR CONTROLLER/DRIVER

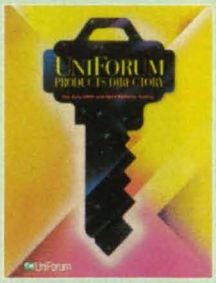
HIGH PERFORMANCE, INTELLIGENCE AND RELIABILITY

For more information on other products available, please contact:

ACS ADVANCED CONTROL SYSTEMS CORP.
Tel: (617) 740-0223 Fax: (617) 740-4227

For More Information Circle No. 572

THE ONLY UNIX AND OPEN SYSTEMS SOURCE



Why look anywhere else?

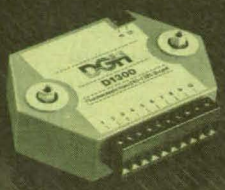
If it's not in the *1992 UniForum Products Directory*, chances are you won't find it elsewhere. The 1992 Directory features 7,600 products and services from 2,100 vendors. We've got it all. More software. More hardware and peripherals. More developers, consultants, books and headhunters than available anywhere else. Only $95.

To order, call 800-255-5620

UniForum The International Association of Open Systems Professionals
2901 Tasman Dr., #201
Santa Clara, CA 95054
(800) 255-5620 (408) 986-8840 Fax (408) 986-1645

For More Information Circle No. 426

FINALLY A COMPUTER AT EVERY SENSOR



- Direct sensor to RS-232C/RS-485
- Digital output in engineering units
- Digital I/O for solid state relays
- Digital limits and alarm capability
- Simple ASCII commands
- Small size fits in a thermowell

DGH
(603) 622-0452

For More Information Circle No. 382

SPINOFFS

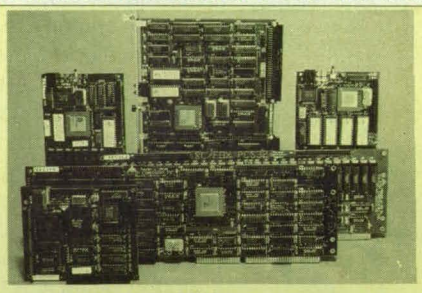
Credit where credit is due!

Transferred/applied NASA technology to a commercial product?

We would like to inform the public about it in our annual report **Spinoff**.

For more details call: (410) 859-5300 Ext.242.

For More Information Circle No. 582



SC/FOX™ Embedded-System Computers

SC/FOX VME SBC (Single Board Computer) 18 MIPS, 60 MIPS burst, general-purpose, slot-1 Master/Slave System Controller. Up to 640K bytes 0-ws memory, 1 SCSI, 1 ptr, 2 serial ports. Uses 16-bit Harris RTX 2000.

SC/FOX PCS (Parallel Coprocessor System) 15 MIPS, 50 MIPS burst, general purpose PC/AT/386 plug-in board, 32K to 1M byte 0-ws static memory, multiple PCS operation, SCSI option. Uses Harris RTX 2000.

SC/FOX SBC (Single Board Computer) 18 MIPS, 60 MIPS burst, Stand-alone operation, Eurocard size, 1 ptr, 1 serial port, up to 512K bytes O-ws memory, 2 50-pin user connectors, SCSI option. Uses Harris RTX 2000.

SC/FOX PCS32 (Parallel Coprocessor System 32) 15 MIPS to 70 MIPS, general-purpose PC/AT/386 32-bit plug-in board with 64K to 1M byte 0-ws static memory. Uses 32-bit SC32 Forth microprocessor.

Ideal for embedded real-time control, data acquisition, or high-speed processing. Forth software included, C optional. OEM pricing.

SILICON COMPOSERS INC *(415) 322-8763*
208 California Ave., Palo Alto, CA 94306

For More Information Circle No. 488

FREE! 130 Page Catalog

"Optics for Industry"

Free 130 page product catalog from Rolyn, world's largest supplier of "Off-the-Shelf" optics. 24-hour delivery of simple or compound lenses, filters, prisms, mirrors, beamsplitters, reticles, objectives, eyepieces plus thousands of other stock items. Rolyn also supplies custom products and coatings in prototype or production quantities. **ROLYN OPTICS Co.**, 706 Arrowgrand Circle, Covina, CA 91722-2199, (818)915- 5707 FAX (818)915-1379

For More Information Circle No. 551

Instant Microcontroller

Instant C Programming

Don't use a microprocessor, use a **SmartBlock**™ microcontroller module to build your custom controller. Our $195 interactive **Dynamic C**™ development system makes programming easy. 3.5 x 2.5 inch module includes microprocessor, memory, time/date clock, eeprom, watchdog, serial ports and more. As low as $59 in quantity. The efficiency of a custom design without the headaches.

Z-World Engineering
1724 Picasso Ave., Davis, CA 95616 USA
Tel: **(916) 757-3737**
Regular Fax: (916) 753-5141
Automatic Fax: (916)-753-0618
(Call from **your fax**, request data sheet #14.)

For More Information Circle No. 489

FREE CATALOG!

LINEAR MOTION COMPONENTS

All products ship within 24 hours.

- Ball Slides
- Crossed Roller Slides
- Positioning Slides
- Recirculating Bearings
- Shafts & Supports

Call TOLL FREE:
1-800/447-2042
In CT: 203/790-4611
or FAX: 203/748-5147

TUSK *DIRECT, INC.*
Clarke Industrial Park, PO Box 326, Bethel, CT 06801

For More Information Circle No. 625

More than 450 pages of tooling components!

FREE!

This illustrated complete line catalog includes component parts for jigs and fixtures, chuck jaws, plug gauges, threaded inserts, stainless steel tooling components, toggle clamps, SWIFTSURE power workholding devices, drill jig bushings, locking pins, and modular fixturing. Completely illustrated. **Send for your free copy.**

Carr Lane MANUFACTURING CO.
4200 Carr Lane Ct. P.O. Box 191970
St. Louis, Missouri 63119-2196
Phone: 314-647-6200, FAX: 314-647-5736

For More Information Circle No. 390

High-Temp Ceramic Adhesives/Putties to 3200 Degrees F

Aremco's high temperature ceramic adhesives/putties are unique asbestos-free, inorganic based materials used to bond, patch, seal and fill ceramics, metals, glass, graphites and composites at temperatures to 3200 degrees F.

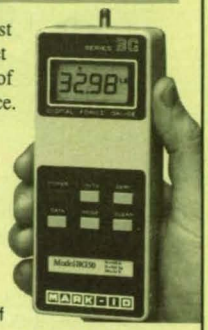
ASK FOR FREE MATERIALS CATALOG FOR INFORMATION ON AREMCO'S HI-TEMP CERAMIC MATERIALS

Aremco Products, Inc.
P.O. Box 429, Ossining, NY 10562
Tel: (914) 762-0685, Fax: (914) 762-1663

For More Information Circle No. 650

FORCE GAUGE

Here it is! The smallest force gauge on the market with the highest number of features at the lowest price.



- Cast aluminum housing.
- RS-232, Mitutoyo and analog outputs.
- External trigger mode.
- Peak memory
- Dual set points.
- Configurable filters.
- Configurable auto-shutoff and auto-transmission.
- 9V NiCd battery.
- *Much, much more...*

$975.00

Interested? Give us a call!

MARK-10

458 West John Street, Hicksville, NY 11801
Tel (516) 822-5300 • FAX (516) 822-5301

For More Information Circle No. 653

Measures Potentially Hazardous Electromagnetic Radiation

A new, portable low-level AC electromagnetic field radiation monitor equipped with a wand sensor that lets users measure ambient fields and view the results simultaneously.

Walker's ELF-66D Field Monitor permits two measurement levels: LO which has a full-scale capability of 200 milliGauss RMS with 0.1 milliGauss resolution and HI for 20 Gauss RMS with 10 milliGauss resolution. Featuring a separate wand sensor with a 6 ft. cable, users can measure wide ambient fields and easily view the results on a large 0.7", 3-1/2 digit LCD display.

For further information contact:

WALKER SCIENTIFIC INC.
Rockdale St., Worcester, MA 01606
Phone: 508/852-3674 FAX: 508/856-9931

For More Information Circle No. 657

***FREE* Catalog and Demo Disk**

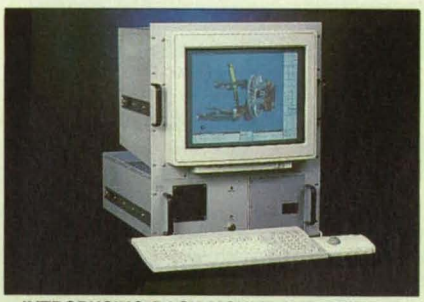
***$49.95* Evaluation Kit**

The fastest real time data acquisition and analysis systems for your PC can be found in our FREE catalog. We feature 50,000 Hz throughput to disk and display simultaneously, but seeing is believing. Order an Evaluation Kit, or call for complete information today.

1-800-553-9006

***DATAQ** INSTRUMENTS, INC.*
150 Springside Drive, Suite B220
Akron, OH 44333
Tel (216) 668-1444 Fax (216) 666-5434

For More Information Circle No. 655



INTRODUCING RACK MOUNT AND RUGGED SUN SPARC WORK STATION

Standard Features Include:

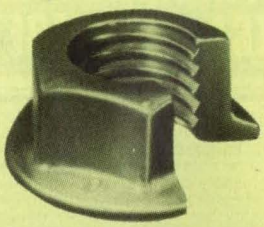
- Spark Engine 2 CPU with 16MB RAM
- 207 MB Hard Disk, 150MB Tape Drive
- 644 MB CDROM, Removable Hard Disk
- 1.44 MB Floppy, 2 RS-232 and S Bus Ports
- SCSI-2 and Ethernet Interface
- 16-inch Rack Mount Color Monitor
- Keyboard, Mouse and SunOS 4.1

For further details contact:

IBI Systems Inc., 6842 NW 20M Ave., Ft. Lauderdale, FL 33309, 305-978-9225, Fax: 305-978-9226

For More Information Circle No. 661

When you're hanging by a thread...



Make sure it's Spiralock.®

The only flange nut featuring the patented Spiralock® self-locking thread form. How well do they resist loosening under vibration? Ask NASA. They use almost 750 in each orbital main engine. Because they know what performance hangs on.

DETROIT TOOL INDUSTRIES
Madison Tech Center • 25219 Dequindre Road
Madison Heights, MI 48071-0629
Phone (313)543-7800 / Fax (313)543-1403

For More Information Circle No. 665

Get AutoCAT for only $495.00!

Software for IBM™ or compatible computers to Automate Computer Aided Tests.

- Performs production tests and lab measurements.
- Interfaces with IEEE-488, RS 232 devices.
- Mouse, pull-down menus, on-line help.
- No programming knowledge required.
- IEEE board available for only $195.00

NEOS

4451B Enterprise Court • Melbourne, FL 32934
Ph: (407) 259-2090 Fax: (407) 255-0274

For More Information Circle No. 669

MIL-STD-1553

TEST EQUIPMENT

- Complete error injection/detection capability for 1553 A/B terminals and systems
- Simulates a Bus Controller, up to 32 Remote Terminals and/or a Bus Monitor
- Supports all phases of testing: Development, Validation and Production
- Dynamic/Real-time simulation

2-DAY SEMINAR

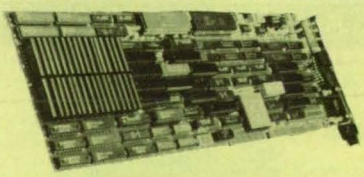
- Comprehensive discussion of MIL-STD-1553 and testing
- Lab session illustrates 1553 communication and provides experience in trouble-shooting
- Offered in Phoenix three times a year and available on-site

VALIDATION TESTING

- Approved by the Air Force
- Testing to the RT VALIDATION TEST PLAN
- Approved test procedure and test report
- Assistance in analyzing test results and trouble-shooting

TEST SYSTEMS, Inc.
217 W. Palmaire • Phoenix, AZ 85021 • (602) 861-1010
Supporting MIL-STD-1553 since 1979

For More Information Circle No. 672



4 MEG VIDEO Model 10

Flexible Image Processor and Application Accelerator For The PC/AT

- 8 to 8000 Pixels per Line
- 2 to 19 MHz sampling/display rate
- 10 MIPs Programmable Accelerator
- 4 Megabytes of Reconfigurable Image Memory
- RS-170, RS-330, and CCIR input/output
- Variable timing for nonstandard formats
- Genlock to external timing sources
- Analog or digital inputs
- Software programmable timing/resolution

EPIX®

3005 MacArthur Blvd., Northbrook, IL 60062
708-498-4002 FAX: 708-498-4321

For More Information Circle No. 675

Subject Index *(Continued from page 157)*

S

T

V

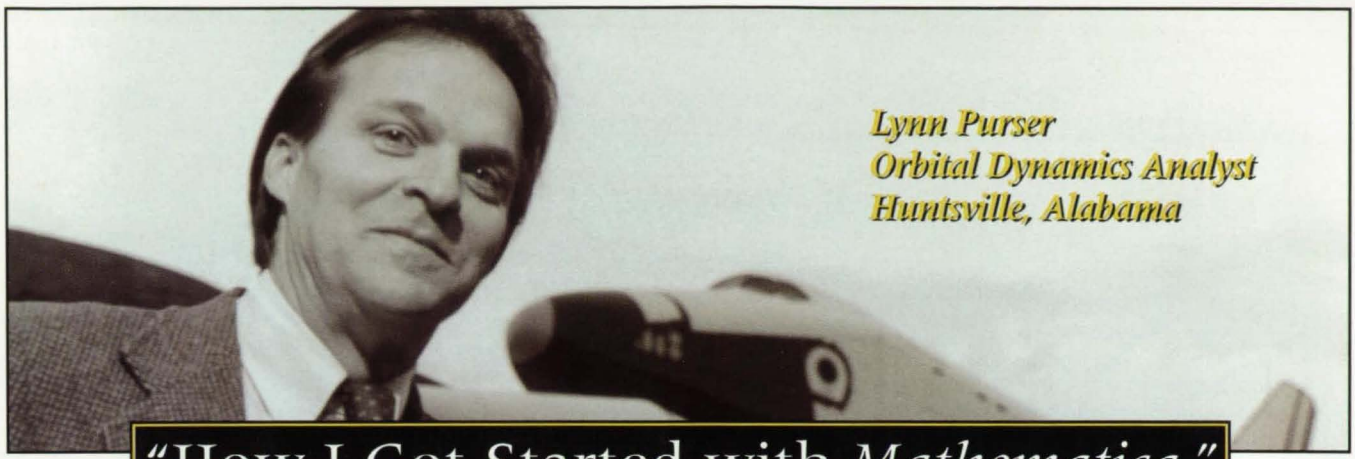
W

ADVERTISERS INDEX

***RAC** stands for **Reader Action Card.** For further information on these advertisers, please circle the RAC number on the Reader Action Card in this issue. This index has been compiled as a service to our readers and advertisers. Every precaution is taken to insure its accuracy, but the publisher assumes no liability for errors or omissions.

NASA Tech Briefs, ISSN 0145-319X, USPS 750-070, copyright © 1992 in U.S., is published monthly by Associated Business Publications Co., Ltd., 41 E. 42nd St., New York, NY 10017-5391. The copyrighted information does not include the (U.S. rights to) individual tech briefs which are supplied by NASA. Editorial, sales, production and circulation offices at 41 East 42nd Street, New York, NY 10017-5391. Subscription for non-qualified subscribers in the U.S. , Panama Canal Zone, and Puerto Rico, $75.00 for 1 year; $125.00 for 2 years; $200.00 for 3 years. Single copies $10.00. Foreign subscriptions one-year U.S. Funds $150.00. Remit by check, draft, postal, express orders or VISA, MasterCard, and American Express. Other remittances at sender's risk. Address all communications for subscriptions or circulation to NASA Tech Briefs, 41 East 42nd Street, New York, NY 10017-5391. Second-class postage paid at New York, NY and additional mailing offices.

POSTMASTER: please send address changes to NASA Tech Briefs, 41 East 42nd Street, Suite 921, New York, NY 10017-5391



Lynn Purser
Orbital Dynamics Analyst
Huntsville, Alabama

"How I Got Started with *Mathematica*®"

I admit, when I first read about *Mathematica*, I was a little skeptical. I guess mathematicians are like anybody else. Sort of like auto workers being replaced by robots—some mathematicians were skeptical of something that might replace them. So when my firm offered an in-house training seminar on *Mathematica*, I decided to see what all the talk was about.

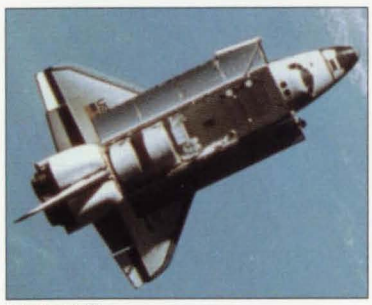


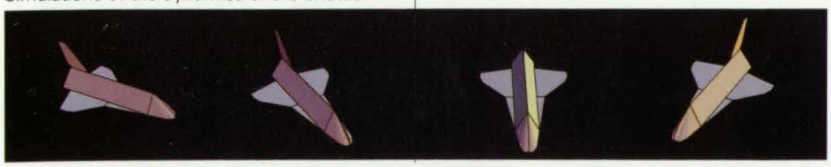
Photo Courtesy of NASA

That class was fun. I tried to do things beyond what the teacher was covering—the rudimentary stuff about *Mathematica* syntax. I wanted to do animation and play with the graphics. I was taken with the visual dimension of it.

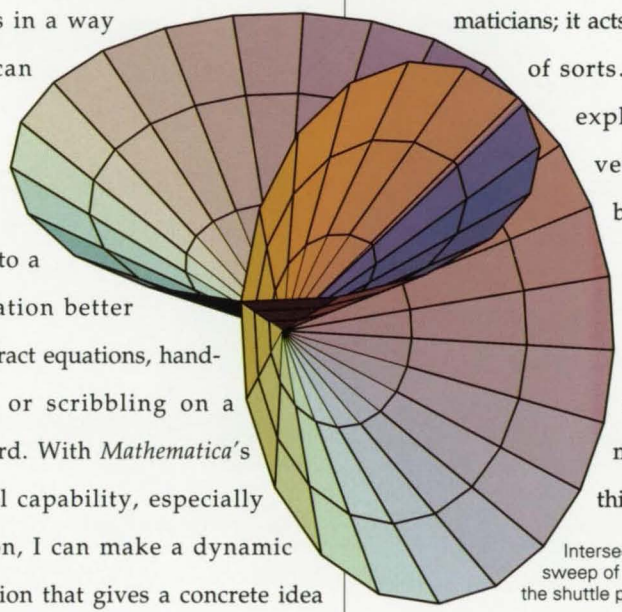
Working on NASA projects, I have to solve problems and present my solutions in a way others can understand. People respond to a visualization better than abstract equations, hand-waving, or scribbling on a blackboard. With *Mathematica*'s graphical capability, especially animation, I can make a dynamic presentation that gives a concrete idea of what I'm talking about.

Then there's the symbolic power. For example, the first project I tackled with *Mathematica* involved a nasty algebraic equation. I solved it on my own and then let *Mathematica* solve it. We both came up with the same answer. But my solution took a few hours and *Mathematica*'s took a few minutes.

Simulations of the dynamics of the shuttle.



Now I use *Mathematica* regularly. I don't think it will ever replace mathematicians; it acts as an assistant of sorts. It helps you explore and develop concepts, by handling the tedious details. In that way, you're free to concentrate on more important things.



Intersection of fields of sweep of two sensors in the shuttle payload bay.

Mathematica is available for: MS-DOS, Microsoft Windows, Macintosh, CONVEX, DG AViiON, DEC VAX (ULTRIX and VMS), DEC RISC, HP 9000, HP Apollo, IBM RISC System/6000, MIPS, NeXT, Silicon Graphics, Sony, Sun-3, and SPARCstations.

Prices in U.S. and Canada start at $595.

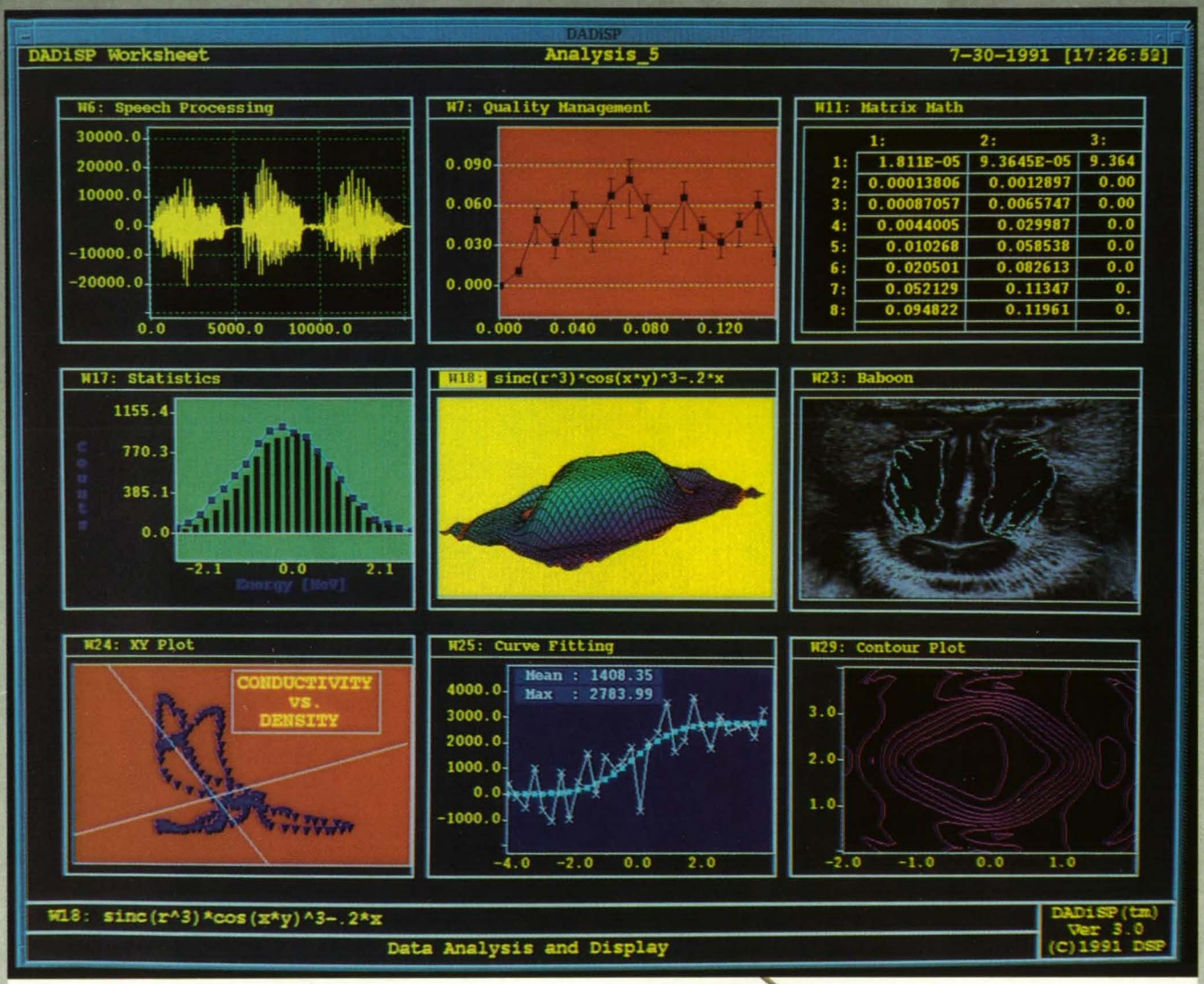
Educational discounts are available.

Orders: 1-800-441-MATH

Mathematica® 2.0
The Standard for Technical Computing

Wolfram Research, Inc., 100 Trade Center Drive, Champaign, IL 61820-7237, USA; 1 (217) 398 0700; fax: 1 (217) 398 0747; email: info@wri.com
Wolfram Research (UK) Ltd., P.O. Box 114, Abingdon, Oxon OX13 6TG, United Kingdom; +44 (235) 550 440; fax: +44 (235) 550 445; email: info-uk@wri.com

The Big Picture Just Got Bigger!



DADiSP 3.0

The Standard Worldwide — adopted by thousands of scientists and engineers for data analysis and graphics.

Just Point-and-Click...

DADiSP works the way you do — from input to output. DADiSP's point-and-click menus put *you* in control: from Data Collection, Reduction and Management, through *Visual* Data Analysis and Hypothesis Testing, on to final output with DADiSP's *outstanding* Presentation Quality Graphics.

DADiSP is currently in use in engineering, laboratory data collection, matrix processing, manufacturing, science, signal processing, chemical and mechanical applications in automotive, aerospace, defense, medical, and other industries.

CALL

1-800-777-5151

for your free DADiSP Trial Kit. DADiSP is available for SUN, HP, IBM, NeXT, DEC, Concurrent, and Silicon Graphics workstations, and of course, IBM PC compatibles.

DSP Development Corporation

One Kendall Square, Cambridge, MA 02139
617-577-1133, FAX: 617-577-8211

For More Information Circle No. 622

Australia-Interworld Electronics, (03) 563-7066; **Belgium**-Electronique-Mesures, (02) 384-7309; **Denmark**-Engberg, (042) 25-1777; **Finland**-Mespek OY, (9) 0-351-1800; **France**-SM2i, (01) 34-89-78-78; **Germany**-Digi-Logger, (07720) 38022; Informatik Systeme, (0631) 35119-0; Ingenieurburo Kohler, (069) 9765-000; PDV-Systeme, (05321) 80761; **Hungary**-Selectrade Computer, (01) 163-2905; **India**-Dynalog Microsystems, (022) 517-0514; **Israel**-Racom, (03) 491922; **Italy**-BPS Computers, (02) 612-90221; BRM Italiana, (011) 771-00-10; **Japan**-Astrodesign, (044) 751-1011; **Korea**-Echo Microsystems, (02) 704-5378; **Netherlands**-Computer Engineering Roosendaal, (01650) 57-417; **New Zealand**-GTS Engineering, (09) 3092-464; **Spain**-Novatronic, (04) 452-0811; **Sweden**-SYSTEC, (013) 11-01-40; **Switzerland**-Urech & Harr, (061) 61-13-25; **Taiwan**-Advantech, (02) 351-2117; **U.K.**-Adept Scientific, (0462) 480055